CONNECTICUT RIVER FLOOD CONTROL PROJECT

SPRINGDALE DIKE
AND
PUMPING STATION

HOLYOKE, MASS.

DEFINITE PROJECT REPORT

ITEM HI. 4

WAR DEPARTMENT   CORPS OF ENGINEERS   U. S. ARMY
U. S. ENGINEER OFFICE   PROVIDENCE, R.I.

MARCH 1945

DEFINITE PROJECT REPORT

ON

SPRINGDALE

(HOLYOKE)

CONNECTICUT RIVER BASIN

MASSACHUSETTS

PREPARED IN THE U.S. ENGINEER OFFICE

PROVIDENCE, R.I. DATED 31 MARCH 1945

APPROVED BY THE CHIEF OF ENGINEERS ______ 194__

E.D. FILE ______

WAR DEPARTMENT CORPS OF ENGINEERS U. S. ARMY

U. S. ENGINEER OFFICE PROVIDENCE, R.I.

REVISIONS

DATE	NEW PAGES OR DRAWINGS	DATE APPROVED BY C. OF E.

DEFINITE PROJECT REPORT
ON
SPRINGDALE (HOLYOKE), CONNECTICUT RIVER BASIN, MASS.

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DEFINITE PROJECT REPORT
ON
SPRINGDALE (HOLYOKE), CONNECTICUT RIVER BASIN, MASS.

1. PERTINENT DATA (Elevations refer to mean sea level datum).

a. Location. - In the southern portion of the City of Holyoke, Massachusetts, on the west bank of the Connecticut River, 85 miles from its mouth.

b. Area protected

Area	128 acres
Type of land	(Industrial (Residential (Commercial (Public park
Maximum flow of record (March 1936)	253,000 c.f.s.
Modified design flood peak	218,000 c.f.s.

c. Earth dike

Method of construction	Rolled fill
Total length	3,684 ft.
Top width	10 ft.
Riverside slope	1 on 2-1/2
Landside slope	1 on 2-1/2

Design flood elevations

Upstream end	70.1 ft.
Downstream end	69.5 ft.

Elevation top of dike

Upstream end	75.1 ft.
Downstream end	74.5 ft.

d. Concrete flood wall

Type of wall	Cantilever
Total length	350 ft.
Height of wall	7' - 6"
Design flood elevation	70.1 ft.
Elevation top of wall	73.2 ft.
Stage of maximum flow of record (March 1936)	approximately 72.4 ft.

e. Berkshire Street sewer

Type	Pressure conduit
Diameter of sewer	9' - 6"

f. Pumping station

Drainage area - - - - - - - - - - - - -	175 acres
Design inflow (including seepage) - - -	86 c.f.s.
Seepage through dike (max.) - - - - - -	19 c.f.s.
Proposed pump capacity	
Zero static head - - - - - - - - - -	102 c.f.s.
17 foot head - - - - - - - - - - -	91 c.f.s.
Number of pumps - - - - - - - - - - - -	2
Type of pumps - - - - - - - - - - - - -	Volute
Size of pumps - - - - - - - - - - - - -	24-inch
Elevation, top of dike opposite pumping station - - - - - - - - - -	74.8 ft.
Maximum design flood stage elevation - -	69.8 ft.
Operating floor elevation - - - - - - -	58.5 ft.
Maximum water surface (zero damage elevation) - - - - - - - - - - -	53.0 ft.
Low water elevation in suction chamber	49.0 ft.

2. SYLLABUS. - a. The proposed project consists of reconstructing approximately 3,684 linear feet of earth dike and the construction of approximately 350 feet of concrete floodwall, a pumping station, and an outfall conduit. The dike, when completed, will protect an area of approximately 128 acres consisting of industrial, residential, and commercial developments and a large public park.

b. The project was authorized under the Flood Control Act approved 18 August 1941 (Public No. 228, 77th Congress, 1st Session). The total estimated cost is $391,000 to the United States and $18,000 to local interests. It is estimated that this project could be completed within one construction season. However, for reasons of economy, this project will be combined under a single contract with the approved flood protection project for the south end of the City of Holyoke, now under design. The estimated construction time for the combined project is three years. Confirmation of full cooperation will be required from the local authorities before construction commences.

c. Preparation of this Definite Project Report was authorized in the second indorsement "Subproject for Springdale Dike, Holyoke, Connecticut River Basin, Massachusetts" from Office, Chief of Engineers, dated 29 September 1943, File 800.524 (Conn. River, Holyoke, Mass.) CE SPEKH.

3. PROJECT AUTHORIZATION. - a. The project is included in the Second Interim Report on the control of floods in the Connecticut River Basin which has been published as House Document 724, 76th Congress, 3rd Session and was authorized in the Flood Control Act approved 18 August 1941 (Public No. 228, 77th Congress, 1st Session).

b. The Springdale Dike is a local integral protective unit and provides for the protection of a low lying park, industrial, residential and commercial areas. Its grades are dependent upon flood reductions that would be attained by proposed upstream reservoirs included in the Connecticut River Flood Control Project.

c. The authorization for construction of this project is subject to the provisions that responsible local agencies give assurances satisfactory to the Secretary of War that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the project, bear the expense of local drainage works, hold and save the United States free from claims for damages resulting from the improvement, and maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of War.

4. INVESTIGATIONS. - Suitable topographic surveys have been made including surface contours at 2 foot intervals, and the locations, elevations and capacities of existing storm and sanitary sewers. The proper City officials were consulted to obtain all necessary pertinent information regarding the existing dike and pumping station and underground structures. Adequate subsurface investigations consisting of bore holes, auger holes and test pits were made to determine the characteristics of the underlying soil in the existing dike, in the embankment foundation and in proposed borrow areas. U.S.G.S. and City maps were consulted for developing drainage areas. A number of studies were made of various alignments, grades, layout of structures and structural details before adopting the project as indicated in this report.

5. LOCAL COOPERATION. - a. The items of local cooperation required are that responsible local agencies (1) provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the project; (2) bear the expense of local drainage works; (3) hold and save the United States free from damages due to the construction works; (4) maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of War.

b. The local authorities have stated informally that full cooperation will be given in all matters pertaining to the Springdale Project such as providing rights-of-way, bearing expense of local drainage works, assuming responsibility for damages, and maintaining and operating the flood protective works after completion and acceptance. Prior to the initiation of actual construction of the project works, definite assurances will be obtained from the City authorities that all the requirements of the Flood Control Act will be complied with.

c. Past experience of the Providence District Office in dealing with the Holyoke authorities has been that the City has the financial ability to meet financial obligations, has on previous occasions produced necessary agreements and assurances, and in practice the City has maintained the completed flood control works in a satisfactory manner. Representatives of the District Office have conferred with the City officials and have found that their desires and requirements are reasonable and can be met in the designs and construction.

d. The names and addresses of the local interests involved in the fulfillment of the conditions of local cooperation and their principal officers and representatives are as follows:

Mayor
Mr. Henry J. Toepfert
City Hall
Holyoke, Massachusetts

City Engineer
Mr. Edward A. Mahor
City Hall Annex
Holyoke, Massachusetts

Chairman, Board of Assessors
Mr. Henry M. LaFontaine
City Hall
Holyoke, Massachusetts

Chairman, Board of Public Works
Mr. Stewart R. Allen
City Hall
Holyoke, Massachusetts

Assistant Manager, Holyoke Gas and Electric Department
Mr. Frank J. Kirkpatrick
Holyoke Gas and Electric Department
Holyoke, Massachusetts

6. DEFINITE PROJECT PLAN. - a. Location and description of the area affected. - Springdale is in the southern portion of the City of Holyoke, Massachusetts, in Hampden County, on the west bank of the Connecticut River, 85 miles from its mouth as shown on Plates Nos. 8 and 9. An aerial photograph of the site appears as Plate No. 3. The principal business activities within the area protected by the combined Springdale and Holyoke Dikes are paper manufacturing plants, worsted mills, and miscellaneous small industries. The Springdale area consists chiefly of industrial, residential and commercial developments and a large public park. Since the construction does not fall within the limits of any public roads, there will be no traffic problems at this site.

b. Existing dike protection. - After the 1927 flood, the City of Holyoke constructed the Springdale Dike which was raised after being overtopped by the 1936 flood. Behavior during the 1938 flood in which crevices as much as 10 inches wide and more than 5 feet in depth occurred in the top of the dike, led to the conclusion that extensive improvements and raising will be necessary to protect the area against floods of the magnitude of the design flood indicated in subparagraph c below.

d. Proposed dike protection. - (1) The limits of the area subjected to inundation by the 1936 flood, the maximum of record at this location, and the proposed plan of protection are indicated on Plate No. 8. The plan of improvement involves the enlargement and reconstruction of approximately 3,684 linear feet of earth dike, and the construction of approximately 350 feet of concrete wall and of a system of collector drains, and a new pumping station near the existing station. The existing pumping station will be removed.

(2) The design or project flood as included in the Authorized Comprehensive Plan system of reservoirs for the Connecticut River is 218,000 c.f.s. The maximum flow of record, 253,000 c.f.s., occurred in March 1936. The approximate stages of these flows at the dike site and the proposed top of dike elevations are as follows. Grades are straight lines between elevations shown:

	Elevation at Upstream End M.S.L.	Elevation at Downstream End M.S.L.
Stage of design flood	70.1	69.5
Stage of maximum flow of record (March 1936)	72.4 approximately	
Stage of flood of September 1938	69.6 approximately	
Top of proposed dike	75.2	74.5

The elevations given for top of dike are for earth dike. The project top of dike grade is designed, with the aid of the proposed system of reservoirs, to protect against a maximum predicted, or "design" flood, with a freeboard of five feet. Where concrete walls are used, top of wall elevations will be 2 feet lower than elevations indicated above. However, the concrete walls will be designed to withstand a flood grade 2 feet higher than the top of wall, in accordance with instructions from the Office of the Chief of Engineers issued subsequent to the 1938 flood.

d. Pumping facilities. - As indicated on Plate No. 19, the proposed pumping station will replace the existing pumping station in discharging the effluent from an area of 175 acres and will include storm runoff, sanitary sewage and seepage through and under the dike. The proposed pumping station will have a capacity of 102 c.f.s., zero static head. The capacities of the pumps were determined as explained in Paragraph 7 c (4), page 9.

e. Berkshire Street sewer. - (1) This sewer was originally a 10-foot diameter brick conduit. In 1937 the City of Holyoke constructed a 3-inch reinforced gunite lining to permit the sewer to function as a pressure conduit commencing at a manhole approximately 1700 feet from the river where the ground is at Elev. 70.2. At this manhole, inlets from several drop inlets enter the sewer. The rim of the lowest of these is at Elev. 70.5 or 0.4 feet above the stage of the design flood. The City will be required to maintain, reconstruct, improve and modify the conduit where necessary.

(2) The safety of the Springdale area is partially dependent on the integrity of the Berkshire Street sewer as a pressure

conduit. Examination of the City's plans for the sewer lining, indicates that the work appears to be well designed and will probably function adequately in withstanding the pressures to which it will be subjected.

(3) The structure which combines the flood wall and sewer at their intersection, as shown on Plate No. 23, contains a stop-log groove which will provide a measure of protection against flooding in the event of failure of the pressure conduit.

f. Alternate schemes. - The following alternative features of construction were considered and discarded for the reasons stated. Reference is made to Plate No. 8.

(1) A pumping station to pump the combined storm and sanitary effluent from the 9-1/2 foot diameter Berkshire Street sewer into the river during floods was found to be uneconomical.

(2) Diversion of sewage from the Berkshire Street sewer into the Second Level Canal during high river stages was found to be infeasible for reasons of sanitation and danger of overflowing the banks of the Canals.

(3) Utilization of the existing pumping station is impractical because the equipment is inadequate to meet the requirements.

7. STRUCTURES AND IMPROVEMENTS. - a. Earth dike section. - (1) The earth dike construction occurring between approximately Stations 8+83.7 and 45+68, as shown on Plates Nos. 13 to 16 inclusive, will consist of improvements and raising of an existing dike as indicated in the sections on Plates Nos. 17 and 18. Between Stations 8+83.7 and 27+00, the plan proposed consists of the removal of a portion of the riverside slope of the existing dike and replacing with an impervious blanket laid on a slope of 1 vertical to 2-1/2 horizontal; installing a steel sheet pile cutoff; raising the crest to the design grade, using a 10-foot top width; placing additional random and pervious material to fill out the landside face to a slope of 1 vertical to 2-1/2 horizontal; and the construction of a gravel toe drain and sewer to collect and dispose of seepage and ground water.

(2) Between Stations 27+00 and 45+68, the existing dike will be partially removed and a new dike constructed an average distance of 75 feet landward from the present position. The reasons for constructing a new dike within this range are:

(a) The foundation conditions within this reach occurring under the existing dike are particularly unfavorable and are believed to be the chief cause of the near failure during the 1938 flood when severe sloughing and cracking of the dike occurred. This near failure is discussed in Appendix III, Paragraph B4, page III-7.

(b) Soundings in the river, observations of the surface condition of the foreshore, and the alignment of the Connecticut River indicate that active erosion of the river bed and bank are probably occurring in this vicinity. In order to forestall the failure of the dike owing to bank erosion, it is believed advisable to reconstruct the dike a reasonable distance landward.

(c) The nature and value of the land involved in the required right-of-way for the new dike alignment are such that no costs to the local interests are involved. Loss of a portion of the partially developed recreational area are believed to be more than compensated for by the more adequate protection and lower maintenance costs that will be provided by the new dike.

(3) The slopes of the dike will be topsoiled and seeded, the crown will be provided with a gravel access road throughout its length for maintenance and emergency purposes. Ramps will be provided near both ends of the dike to provide access from the landside of the dike to the top of the dike.

(4) Large trees exist in the foreshore adjacent to the dike. These trees are considered beneficial in supporting the soil and reducing water velocities adjacent to the dike. It is proposed to supplement the existing trees with new trees where necessary and to require the local interest to maintain the growth.

b. Concrete wall section. - (1) As shown on Plate No. 13, the section of Springdale dike between approximately Stations 3+32 and 6+82.8 will consist of removing the top portion of the existing dike and constructing a new reinforced concrete wall of the cantilever type. The reasons for constructing a concrete wall within this reach are:

(a) The available space between the water's edge and an existing railroad spur is insufficient for the construction of a dike having a greater height and flatter slopes than the existing embankment.

(b) It is planned to construct the concrete wall in order to avoid involvements with the railroad and lateral flood control structures, and to avoid unnecessary overlaps between earth and concrete structures, and to be consistent with the type of flood control structure to be constructed immediately upstream of Station 3+32, as part of the Holyoke flood protection. A typical concrete section is shown on Plate No. 17.

(2) The existing concrete wall between Stations approximately 6+82.8 and 8+83.7 will be capped about 1/2 foot to bring it up to design grade.

c. Pumping Station. - The pumping station will have sufficient capacity to discharge storm runoff, sanitary flow, and seepage through the dike. Two pumps will be used having a combined pumping capacity of 102 c.f.s. at zero static head. A 42-inch cast iron conduit will be provided for both gravity flow and pump discharge as indicated on Plate No. 19. Pumping will begin normally when the Connecticut River reaches Elev. 53.0 M.S.L. The discharge conduit will have a gate structure near the riverside toe of the dike with a manually operated gate to prevent damage by backflow in the event of structural failure of the discharge conduit or mechanical failure of the sluice gate at the upstream end of the discharge conduit. The arrangement of the pumping equipment is shown on Plates Nos. 20 and 21.

d. Sewer connections. - As shown on Plates Nos. 8 and 19, the existing pumping station and appurtenant sewer connections will be abandoned. A junction chamber will be constructed in the existing 42-inch diameter Front Street outfall sewer to provide a connection for the intake conduit for the proposed pumping station. Downstream from the junction chamber, a new 42-inch diameter outfall sewer will extend to the river. The discharge conduit will carry both gravity flow and pump discharge.

e. Mechanical and electrical equipment. - (1) General. - In the design of the equipment for the Springdale Pumping Station, primary consideration will be given to simplicity and safety of operation and ease of maintenance. Provisions will be incorporated in the design to protect it from the deleterious effects of condensation of moisture on equipment. Non-corrodible materials will be used insofar as possible. The equipment will be manually controlled throughout all its functions.

(2) Pump drive. - This office constructed four pumping stations which form part of the upper flood protection works at Holyoke, Massachusetts. They were completed approximately four years ago and turned over to local authorities for operation and maintenance. Prior to the design of these stations an investigation was made of the available electric power facilities with the object of employing electric motors as prime movers. The investigation disclosed that there are two independent and dependable sources of power in the community. The two power systems are inter-connected and in turn can be connected to a third system in time of stress. In view of the dependable electric power supply it is proposed to employ electric motors as prime movers at the Springdale Pumping Station. This proposal is concurred in by local authorities.

Power will be delivered to the pumping station substation at 4600 volts, three phase, three wire, 60 cycle, from the Holyoke Gas and Electric Department and 13,800 volts, three phase, three wire, 60 cycle, from the Holyoke Water Power Company. Both these systems in turn can be connected to the lines of the Western Massachusetts Companies.

The pump motors will be solid-shaft, squirrel cage motors of the low-starting current, normal starting torque type, designed for across-the-line starting, and operated on 2300 volts. The motor insulation will be Class "A" construction and will be given special treatment to resist the absorption of moisture. The motors will be provided with drip covers and lifting lugs and will have all metal surfaces properly treated to prevent corrosion.

(3) Motor control. - Metal-clad switchgear with electrically operated drop-out type oil circuit breakers will provide motor control and protection. Oil circuit breakers were selected because of their superior ability to withstand moisture conditions prevalent in the stations. Strip heaters will be installed in each switchgear cubicle. Test blocks will be provided on the circuit breaker relays and directly in the current transformer secondaries to permit periodic inspections and tests on the relays and control system. A test rack will be provided in the station to permit complete inspection and testing of circuit breakers.

(4) Pumps and piping. - The pumps will be of the volute type suitable for pumping sewage and storm water. They will be mounted on cast iron base elbows. The casings will be constructed without stationary guide or diffusion vanes. The casings and impellers will be equipped with bronze wearing rings. Thrust bearings will be incorporated in the pumps. Large quick-opening hand holes will be provided in both the intake elbow and volute casing. A swing check valve will be installed in each pump discharge line to prevent backflow and to facilitate starting. Hand operated solid wedge gate valves will be installed in the pump suction and discharge lines.

No provisions were made in the required capacity determined in Appendix A for possible mechanical failure of equipment. To provide for this contingency it was considered necessary that in the event one pump should fail, the remaining pump should be capable of delivering about 90 percent of the required station capacity.

The required capacity of the pumping station at zero damage elevation 53.0, as determined in Appendix I and indicated on Plate No. 7, is 57 c.f.s. Assuming that two pumps will be installed and applying the above mechanical factor the capacity of each pump is 51 c.f.s. Plate No. 22 shows the maximum station capacity at any head condition.

(5) Sub-station. - A sub-station converting either source of power to 2300 volts for pump operation will be located adjacent to the pumping station. The structure of the sub-station will be of galvanized steel and will provide for switching, fuses, lightning arrestors, and busses. Three transformers will be provided having double-winding primaries - 13,800 volts and 4600 volts - and 2300 volt secondaries. Air switches will be provided on the incoming lines at the sub-station so that either source may be utilized and will be interlocked so that not more than one switch can be in the closed position at a time.

Fuses will be provided in each incoming phase with an interrupting capacity sufficient to interrupt the maximum fault current on the utility's system at that point. The fuses will be coordinated with the circuit breaker relays in the pumping station and with the protective devices of the utility systems so the fuses will operate only on a fault between the fuses and the main circuit breaker in the pumping station.

Lightning arresters will be provided on each incoming phase and connected to a low resistance grounding system at the sub-station.

The 2300 volt secondaries will provide for operation of the pump motors only. A single-phase 4800/240-120 volt transformer will be provided at the sub-station to furnish lighting and any necessary small power for the pumping station. This transformer will be so connected that normally it will be energized by the 4600 volt source, but in the event that a failure of this source occurs, the transformer may be connected to the 4600 volt windings of the double primary power transformer and energized from the 13,800 volt source. This arrangement has the advantage of having energy available at the pumping station at all times for lighting, heating, and miscellaneous maintenance by means of a transformer no larger than necessary, thus permitting the large transformers to be de-energized, except during the periods when the pumps are to be operated, with the consequent reduction of energizing current losses in the main transformer bank.

(6) Traveling crane. - A four-ton overhead crane will be provided in the motor room. The crane will be of standard design and hand operated throughout all its functions.

(7) Sump pump. - A motor operated sump pump will be installed in the pump room to take care of station leakage.

8. FOUNDATIONS. - The ground upon which the existing Springdale Dike is located was used for many years as a dumping ground for miscellaneous debris from factories in the City of Holyoke. Numerous test borings have been made along the proposed alignment to determine the characteristics of the underlying soil. The borings show that practically the entire dike is underlain by fill consisting principally of cinders, but containing also hard coal ashes, bricks, tin cans, wood, coal and other rubbish. Plan and record of subsurface explorations are shown on Plate No. 24. See Appendix II for a discussion of the geology of the site and Appendix III for a discussion of the nature of the foundation and proposed treatment.

9. AVAILABILITY OF CONSTRUCTION MATERIALS. - Suitable materials for the earth dike are available within a reasonable distance of the site. Impervious material can be obtained from the Riverdale Dike borrow area in West Springfield, approximately 3-3/4 miles from the project. Pervious materials, coarse gravel and riprap is obtainable in Holyoke or other nearby commercial sources. It is anticipated that

ready-mixed concrete obtained from local concerns will be used for the concrete structures. Locations of borrow areas are shown on Plates Nos. 25 and 26.

10. CONSTRUCTION TIME REQUIRED AND SCHEDULE OF OPERATIONS. - a. It is estimated that three years will be required for completing the construction of this project. The length of time estimated is longer than that actually required for a project of this magnitude but the construction period will be determined by the time required to complete the remainder of the Holyoke flood protection under a contract which, for reasons of economy, will include the Springdale Dike project. The schedule of operations on page 12 shows the estimated time required for completing the principal elements of the project and also shows the sequence of construction operations proposed and the funds required by fiscal years. For simplicity, this schedule covers the construction of the Springdale Dike as a separate project unrelated to the Holyoke Dike project.

b. It is estimated that 4-1/2 months will be required for preparation of the plans and specifications for this project. The estimated cost of preparing the plans and specifications is $14,000.

c. It is estimated that 450,000 man-hours of employment will be provided by construction of this project. This represents 197,000 man-hours of direct employment at the construction site and 253,000 man-hours of indirect employment. The following tabulation shows the breakdown of man-hours and man-months of employment into general classifications of labor.

ESTIMATE OF EMPLOYMENT

(166 man-hours = 1 man-month)

CLASSIFICATION OF LABOR	DIRECT EMPLOYMENT (on-site labor)		INDIRECT EMPLOYMENT (off-site labor)	
	Man-Hours	Man-Months	Man-Hours	Man-Months
Supervisory	13,800	84	25,300	153
Administrative	4,500	27	12,700	76
Skilled labor	50,500	305	63,200	381
Semi-skilled labor	36,600	220	63,200	381
Unskilled labor	91,600	552	88,600	534
TOTALS	197,000	1,118	253,000	1,525

SCHEDULE OF OPERATIONS

ITEM OF CONSTRUCTION	SEQUENCE OF CONSTRUCTION OPERATION												PAYMENTS TO CONTRACTOR		
	1st Fiscal Year						2nd Fiscal Year						1st Fiscal Year	2nd Fiscal Year	Total
	J	F	M	A	M	J	J	A	S	O	N	D			
Preparation of site													$ 1,000	$ 1,000	$ 2,000
Care of water													5,000	3,000	8,000
Stripping													5,000	0	5,000
Common excavation													8,000	11,000	19,000
Earth excavation, borrow													9,000	22,000	31,000
Embankment, rolled													12,000	28,000	40,000
Steel sheet piling													107,000	0	107,000
Concrete structures													26,000	0	26,000
Toe drainage													14,000	9,000	23,000
Pumping station superstructure													0	8,000	8,000
Mechanical equipment													8,000	32,000	40,000
TOTALS													$195,000	$114,000	$309,000

11. OPERATION AND MAINTENANCE. - a. General. - The mechanical and electrical equipment for the Springdale Project will consist essentially of the pumping equipment in the Springdale Pumping Station and a number of sluice gates and valves used to control storm and sanitary sewers. The City of Holyoke will be responsible for their operation and maintenance subject to the regulations prescribed by the Secretary of War.

b. Arrangement of equipment. - All pumping equipment will be so located that it will be accessible for maintenance and repair with suitable provisions made for its removal in the event that major repairs are required. The equipment in the pump room will be so arranged that any item of equipment requiring removal may be rolled on skids from its permanent location to a location beneath the access hatch in the operating room floor without the necessity of jacking it over other items of equipment to effect its removal.

c. Protection from moisture. - To facilitate maintenance and to combat the deteriorating effects of the moisture conditions a warm-air oil heating system will be provided to heat the operating room, and electric strip-heaters will be installed beneath the pump motors and in each switchgear cubicle. Items which would be difficult to replace and are subject to corrosion, such as anchor bolts for sluice gates, will be of corrosion resistant material.

d. Gauges. - A float gauge, which will indicate the elevation of water in the pump suction chamber will be provided to guide the operator in starting and stopping the pumps. A second gauge, indicating the river stage, will be provided to enable the operator to know the elevation of the flood waters at all times.

e. Trash racks. - Trash racks will be provided in the intake structure to retain any debris that might clog or damage the pumps. Necessary access will be provided to permit cleaning of them by means of a rake from the platform above. A drain pipe will be connected from the pump intake chamber to the sump of the sump pump to permit dewatering of the intake chamber for maintenance purposes.

f. Dike. - The local authorities will be responsible for necessary maintenance such as care of grass on the earth slopes and maintaining the roads on the ramps and top of dike in operating condition.

12. COST ESTIMATES. - a. The various elements comprising the project and the estimated cost of construction of each element follows:

(1) ESTIMATED COST TO THE UNITED STATES

Springdale Dike and Pumping Station		$391,000

(2) ESTIMATED COST TO LOCAL INTERESTS

(a) Paving ramps and constructing access roads	$2,000	
(b) Providing borrow areas	5,000	
(c) Power line relocation	2,000	
(d) Rights-of-way	9,000	
Total		$ 18,000*

(3) GRAND TOTAL ESTIMATED COST $409,000

b. DETAILED COST OF CONSTRUCTION

Preparation of site		Lump Sum	$ 2,000
Care of water		Lump Sum	8,000
Stripping	12,500 cu.yds.	0.40	5,000
Earth excavation, Common	48,000 cu.yds.	0.40	19,000
Earth excavation, Borrow	56,500 cu.yds.	0.55	31,000
Embankment, rolled	100,000 cu.yds.	0.40	40,000
Toe drainage	4,400 lin.ft.	5.25	23,000
Reinforced concrete	1,300 cu.yds.	20.00	26,000
Steel sheet piling	86,000 sq.ft.	1.25	107,000
Pumping station superstructure		Lump Sum	8,000
Mechanical equipment		Lump Sum	40,000
			$309,000
Contingencies 10%			31,000
			$340,000
Engineering and Overhead 15%			51,000
ESTIMATED COST TO THE UNITED STATES			$391,000

* Includes 20% for legal, overhead and general expenses.

13. RECOMMENDATIONS. - The District Engineer recommends that the project as outlined in this report be constructed.

14. BASIS OF DESIGN. - The appendices inclosed herein give detailed accounts and descriptions of the various studies made for the preparation of this report.

W. J. TRUSS
Colonel, Corps of Engineers
District Engineer

Inclosures:
- Appendix I, Hydrology
- Appendix II, Geology
- Appendix III, Soil Data and Analysis
- Appendix IV, Hydraulic Design
- 41 Plates

APPENDIK I

HYDROLOGY

WAR DEPARTMENT
CORPS OF ENGINEERS, UNITED STATES ARMY

CONNECTICUT RIVER FLOOD CONTROL PROJECT

HYDROLOGY REPORT ON THE SPRINGDALE PUMPING STATION AT HOLYOKE, MASS.

United States Engineer Office
Providence, Rhode Island
October 1944.
Revised March 1945.

TABLE OF CONTENTS

I. INTRODUCTION

1. Authority. - This report is submitted pursuant to a directive in 10th indorsement of the Office of the Chief of Engineers, file 7402 (Conn. R.-West Springfield)-25, dated 22 January 1941, subject: Sub-project for construction of flood control works at West Springfield, Massachusetts - Connecticut River Basin, which reads as follows:

> "Hydrology Reports on drainage capacities for the design of pumping stations or other structures connected with interior drainage of levee projects will be prepared and submitted to this office for approval as the first step in the final design of drainage structures".

2. Project. - The local protection works for Springdale in the City of Holyoke, Massachusetts are included in the project for flood protection on the Connecticut River as a part of the comprehensive system for flood control as recommended by the Board of Engineers for Rivers and Harbors in a second interim report published in House Document No. 724, 76th Congress, 3d session, dated 7 May 1940. The project is authorized under the Flood Control Act approved 18 August 1941 which includes both a system of reservoirs in the headwater tributaries of the Connecticut River and a system of local protection works in the lower valley.

3. Status of project. - At Springdale it is proposed to construct a dike and appurtenant works to protect the area which adjoins Holyoke on the south. The pumping station reported upon herein is necessary for interior drainage.

II. HYDROLOGY

A. DRAINAGE AREA.

1. Present development. - At the present time the drainage area, as shown on Plates 1, 2 and 3, consists of 175 acres sub-divided as follows:

a. - 53 acres - Fully developed residential

b. - 32 acres - Park area

c. - 40 acres - Undeveloped residential

d. - 13 acres - Undeveloped residential

e. - 11 acres - Partially developed industrial

f. - 26 acres - Partially developed industrial

2. Future development. - It is considered that protection from floods provided by the dike and the expected post-war expansion of Holyoke will result in accelerated development of the drainage area as follows:

a. - 53 acres - Fully developed residential

b. - 32 acres - Park area

c_1. - 22 acres - Partially developed residential

c_2. - 18 acres - Undeveloped residential

d. - 13 acres - Fully developed residential

e. - 11 acres - Partially developed industrial

f. - 26 acres - Fully developed industrial

3. Topography. - The drainage area includes a flat area on the present flood plain of the river and a moderately steep area which slopes from the railroad toward the present flood plain as shown on Plate 2. The effect of slope on the determination of the subdivisions of the drainage area is shown in the tabulation below.

Sub-Area No.	Area-Acres	Slopes
a	53	Moderately steep
b	32	Flat
c_1	22	"
c_2	18	"
d	13	Moderately steep
e	11	" "
f	26	Flat

4. Sewer facilities. - As determined from the sewer maps of the City of Holyoke and shown on Plate 2, a combined system serves the entire drainage area in its present state of development. The combined interceptor called the Front Street sewer and its branch sewers running east and west on Main Street serve over 80 percent of the drainage area or approximately 142 acres. The remaining area, Riverside Park, is served by a 12" vitrified clay storm drain which discharges into the Connecticut River through the dike. Future extensions of the sewer system are probable.

The capacity of the sewer system was computed for various river stages as shown on Plate 7. In computing the capacity of the existing system consideration was given to permissible surcharge, capacities of mains and laterals and limiting heights of gradient due to controlling basement elevations. It is considered that necessary assumptions were made on a liberal basis so that the computed capacities are high rather than low. It was determined that manhole "F-2" (see Plate 2) and the 42" diameter Front Street sewer were the controlling elements in the determination of capacity. A maximum surcharge of 3 feet at manhole "F-2" was permitted while groundwater levels were assumed equal to Conn. River stage. The maximum water surface at Manhole "F-2" was determined to be El. 55, since excessive damage would be caused at higher elevations.

B. SEEPAGE.

The quantity of seepage through the dike, with the Connecticut River at elevation 73, has been estimated at 18 c.f.s. (See paragraph D-5e.)

C. STORAGE.

It has been determined that a storage pond is not feasible at this location.

D. DETERMINATION OF DISCHARGE CAPACITY.

1. Definitions. - a. Design storm. - Storm of 10-year frequency and required duration used to compute runoff from a given drainage area.

b. Runoff coefficient, C. - The peak rate of runoff due to a storm of given duration (the duration is approximately equal to the time of concentration), having a uniform rate of precipitation of 1"/hr. on a drainage area of 1 acre.

2. Design requirements. - The pumping station shall have sufficient capacity to meet the following requirements.

a. Discharge the peak runoff from the design storm for a given month when pumping against a river stage having a computed frequency of once in 10 years for that month.

b. Discharge the peak runoff from a storm equal to 40% of the design storm for 10-year river stage for a given month when pumping against a river stage having a computed frequency of once in 1000 years for that month.

c. Discharge the seepage which flows to the pumping station through the dike and foundation.

d. Discharge the sanitary sewage and infiltration of ground water.

3. <u>Rainfall</u>. - Rainfall records for a 40-year period at Providence, R. I. were used to determine rainfall intensity-frequency curves for every month in the year for 30-minute, 1-hour and 2-hour storms. It is considered that the Providence rainfall data provide a good basis for design, inasmuch as the Yarnell rainfall curves give approximately equal amounts of rainfall for Holyoke and Providence for various durations and frequencies (refer to Misc. Pub. #204 Dept. of Agriculture, "Rainfall Intensity-Frequency Data" by D. L. Yarnell). Plate 4 shows intensity-frequency curves for 30-minute storms for every month in the year.

4. <u>River stage</u>. - Monthly Connecticut River Stage-Frequency curves shown on Plate 5 were determined by relating stages from similar curves developed for the gage at Memorial Bridge, Springfield, Mass. from records of daily stages covering the period from 1872 to 1939. Plate 6 shows the stage-duration curve for the Connecticut River at Springdale Pumping Station.

5. <u>Discharge analysis</u>. - The peak rates of runoff were computed

by use of the rational formula $Q = CiA$, since there was insufficient basic data available to permit the use of more accurate methods.

a. Runoff coefficient. - Weighted values of C were computed for the months May-October and November-April. Since no runoff records were available, runoff coefficients for the sub-areas were estimated from the usual considerations of size, shape, slopes, type of development, natural and subsurface storage. The computations of weighted values of C for the two design periods of the year are shown in Tables 1 and 2 which follow.

TABLE 1 - PRESENT DEVELOPMENT

Sub-Area No.	Area-Acres	Slopes	C Nov.-April	C May-Oct.	C x Area Nov.-April	C x Area May-Oct.
a	53	Moderately steep	.80	.60	42.4	31.8
b	32	Flat	.40	.30	12.8	9.6
c	40	Flat	.40	.30	16.0	12.0
d	13	Moderately steep	.60	.45	7.8	5.9
e	11	Moderately steep	.60	.45	6.6	5.0
f	26	Flat	.50	.40	13.0	10.4
TOTAL	175				98.6	74.7

Weighted value of C (Nov.-April) = 98.6 ÷ 175 = 0.56

" " " " (May - Oct.) = 74.7 ÷ 175 = 0.43

TABLE 2 - FUTURE DEVELOPMENT

Sub-Area No.	Area-Acres	Slopes	C Nov.-April	C May-Oct.	C x Area Nov.-April	C x Area May-Oct.
a	53	Moderately steep	.80	.60	42.4	31.8
b	32	Flat	.40	.30	12.8	9.6
c_1	22	Flat	.60	.45	13.2	9.9
c_2	18	Flat	.40	.30	7.2	5.4
d	13	Moderately steep	.80	.60	10.4	7.8
e	11	Moderately steep	.70	.50	7.7	5.5
f	26	Flat	.55	.40	14.3	10.4
TOTAL	175				108.0	80.4

Weighted value of C (Nov.-April) = 108.0 ÷ 175 = 0.62
" " " " (May - Oct.) = 80.4 ÷ 175 = 0.46

b. Time of concentration. - In determining the peak runoff from the drainage area, it was necessary to determine the duration of the design storm, which is approximately equal to the time of concentration. The concentration time was determined by selecting the longest course, the sewer line along Main Street, west of Race Street. Approximate computation of the time of concentration indicated that a 30-minute storm would be satisfactory for design.

c. Determination of peak storm flow. - Having determined the weighted values of C, the values of Q can be computed for each month of the year for design rainfall intensities corresponding to 10-year river stages and 1000-year river stages. As indicated in paragraph D-2b, the required design rainfall for a given month corresponding to a 1000-year river stage for that month is 40% of the design rainfall for a 10-year river stage. Since the difference between the runoff coefficients for present development and future development is only about 10 percent, runoff computations have been made for future development only. Table 3 shows the computation of runoff for every month in the year for 10-year and 1000-year stages.

TABLE 3 - FUTURE DEVELOPMENT

Month	30-Min.-10 Yr. Intensity, i In. per hr.	Weighted C	10 Yr. River Stage: Design rate = i	10 Yr. River Stage: Q CFS	10 Yr. River Stage: River Stage M.S.L.	1000 Yr. River Stage: Design rate = 0.40xi	1000 Yr. River Stage: Q CFS	1000 Yr. River Stage: River Stage M.S.L.
Jan.	.83	.62	.83	90.1	52.5	.33	35.8	60.7
Feb.	.64	.62	.64	69.4	51.0	.26	28.2	59.1
Mar.	.62	.62	.62	67.3	58.5	.25	27.1	74.5
Apr.	.76	.62	.76	82.5	59.7	.30	32.5	68.5
May	1.00	.46	1.00	80.5	55.3	.40	32.2	65.1
June	1.42	.46	1.42	114.5	50.2	.57	45.9	58.1
July	2.10	.46	2.10	169.0	47.8	.84	67.5	58.1
Aug.	1.70	.46	1.70	137.0	46.5	.68	54.8	55.0
Sept.	1.73	.46	1.73	139.2	48.4	.69	55.6	70.6
Oct.	.97	.46	.97	78.2	49.8	.39	31.4	64.5
Nov.	1.02	.62	1.02	110.6	50.4	.41	44.5	68.0
Dec.	.72	.62	.72	78.1	52.7	.29	31.5	63.2

The values in Table 3 have been plotted and an envelope curve has been drawn through or outside of the critical points, indicated as curve A on Plate 7.

d. Sanitary sewage and infiltration. - The sanitary sewage and infiltration of ground water were computed as follows:

1. Present development

Designation	Area	Max. Rate	Max. Discharge Million Gallons Daily
Sewage - Fully developed res.-15 persons per acre	53 acres	200 g.p.c.d.	0.16
Sewage - Partially developed industrial area	37 acres	10,000 g.p.a.d.	0.37
Ground water infiltration	2.7 miles pipe	40,000 g.p.m.d.	0.11
		TOTAL =	0.64 or 1.0 c.f.s.

2. Future development

Designation	Area	Max. Rate	Max. Discharge Million Gallons Daily
Sewage - Fully developed res.-15 persons per acre	66 acres	200 g.p.c.d.	0.20
Sewage - Part. developed res.-10 persons per acre	22 acres	200 g.p.c.d.	0.04
Sewage - Part. developed industrial area	11 acres	10,000 g.p.a.d.	0.11
Sewage - Fully developed industrial	26 acres	20,000 g.p.a.d.	0.52
Ground water infiltration	4 miles pipe	40,000 g.p.m.d.	0.16
		TOTAL =	1.03 or 1.6 c.f.s.

e. Dike seepage. - The dike seepage which will reach the pumping station has been estimated at 18 c.f.s. with the river at stage El. 73.0. Seepage was assumed to vary uniformly from zero, (0), at El. 56.0 to 18 c.f.s. at El. 73.0 and to increase uniformly for higher river stages as tabulated below:

River stage	Seepage - c.f.s.
47.8 to 56.0	0
59.7	3.9
70.6	15.5
74.5	19.6

f. Required total discharge capacity. - Since the envelope curve of computed peak runoff, curve "A" as shown on Plate 7, contains values considerably in excess of the capacity of the existing sewer system, it was considered proper to use reduced values in determining the required discharge capacity of the proposed pumping station. The ratio of the capacity of the existing sewer system at a given river stage to the computed runoff at that stage is a maximum at El. 52 (44/117 = 37.6%). An increase of 30% over the existing sewer capacity was considered adequate for computing required pumping capacities. Since this increase of 30% results in a required storm discharge capacity of approximately 50% of the computed runoff (44/117 x 1.3 = 48.9%) at El. 52, the required storm discharge capacity was computed at 50% of the values taken from curve "A" for all river stages. The required total discharge values given in Table 4 below are for critical months and stages only and were obtained by adding the combined values of sewage, infiltration of ground water and dike seepage to 50% of the values of computed peak runoff taken from curve "A". Curve "B", Required Discharge Capacity shown on Plate 7 furnishes the basic data required to determine pump capacities.

TABLE 4

Month	River Stage M.S.L.	Stage Freq. Years	30-min. Runoff from curve "A" c.f.s.	Required Storm Runoff Capacity c.f.s.	Sewage + Infiltration c.f.s.	Seepage c.f.s.	Total c.f.s.
July	47.8	10	169	84.5	1.6	0	86.1
April	59.7	10	82.5	41.3	1.6	3.9	46.8
Sept.	70.6	1000	56.0	28.0	1.6	15.5	45.1
March	74.5	1000	48.0	24.0	1.6	19.6	45.2

TABLE 4

APPENDIX II

GEOLOGY

APPENDIX II

GEOLOGY

C O N T E N T S

APPENDIX II - GEOLOGY

A. GENERAL TOPOGRAPHY AND GEOLOGY OF AREA. The Connecticut valley lowland is a major physiographic part of New England. It is formed in slightly inclined sandstone and shale strata, of Triassic Age, which have been down-faulted or lowered beneath the flanking upland areas of much older folded and crystalline rocks forming the highland regions on the east and west. Protruding above the general area in the western part of the lowland and extending across to the north are a series of sharply defined ridges of intrusive and extrusive lava-diabase flows and dikes. This chain of narrow ridges or mountains is transected at several points by rivers and smaller streams a principal transection being that of the Connecticut River approximately five miles north of the Springdale project. The Connecticut valley lowland is comprised essentially of two valleys (1) a deeply buried geologically ancient and extensive valley described above, which dates back in origin to pre-glacial time and (2) a younger valley superimposed upon the older, this younger valley being formed entirely in glacial sediments. North of the Springdale projects this younger valley is situated on the west side of the deeply buried pre-glacial valley. In cutting down through the glacial overburden the river has reached the underlying bedrock formation and consequently is entrenched in shale rock to a point about 0.5 miles below the Holyoke Dam or about 2 miles upstream of the project limit. Below this point the river channel is entrenched in sediments with confining banks extending from 20 to 25 feet above the river. During high water the river overflows these banks and submerges the flood plain which within the limits of this project varies in width from about 0.1 to 0.5 miles.

B. LOCATION AND DESCRIPTION OF SITE. The Springdale project is located on the right or west bank of the Connecticut River. The area to be protected is an alluvial plain standing at average Elev. 60. The project is essentially a complete reconstruction, of an existing earth embankment, previously constructed under City of Holyoke auspices.

C. SUBSURFACE INVESTIGATIONS. Explorations were made by dry sample borings, most of these borings being accomplished in 1939 and located along the top of the existing levee. These initial borings, six in all, developed the general overall conditions. This information was supplemented later by two other borings located in the vicinity of a possible site for a gate structure and pumping station and by power auger borings. In addition to foundation borings, investigations by borings and test pits have been made also in borrow areas. The location and records of explorations are shown on Plates Nos. 24, 25, and 26.

D. GEOLOGY OF SITE - OVERBURDEN CONDITIONS. - 1. As cited previously the proposed levee or dike will be located on a flood plain adjacent to the right bank. Borings indicate that, throughout much of the extent of levee, the present bank of the river is not a natural deposit but man made consisting of dumped heterogeneous materials, cinders, ashes, brick and miscellaneous earth fill. Along the line of borings, which were located on the top of the previously completed dike, the original ground surface is located at an average depth of about 27 feet or at approximately Elev. 46. The top of the old dike is at Elev. 72.5+. As the flood plain in back of the dike stands at approximately Elev. 60, it is seen that the present dike is located either over the old natural bank or in the vicinity of the top of the old natural bank. The shallowest boring was carried in depth to Elev. 12.7 and the deepest to Elev. -6.1 so that unconsolidated foundation materials are known to be of considerable depth beneath the flood plain and river level.

2. Naturally deposited materials in the foundations consist of stratified sands and sand gravel mixtures. A bedded combination of relatively pervious sands and gravels (Classes 2, 3, 4 and 5 as described on Table No. 1, page III-2) occurs as a prominent formation at Elev. 40+. These pervious materials are underlaid at depths ranging from Elev. 18 to Elev. -10+ by less pervious sand silt and sand and gravel (Classes 6, 7, 8, 9 and 13). Red shale was encountered at one location BH-70 at a depth of 64 feet.

E. FOUNDATION PROBLEM AND PROPOSED TREATMENT. As the earth levee or dike and the short length concrete wall are to be founded on an overburden of coarse granular materials as described in the previous paragraph, the only foundation problem is that concerned with the control of seepage. Three methods of seepage control will be provided (1) sheet pile cut-off for partial depth of the pervious foundations, principally to cut off the portion comprised of unnatural fill, and (2) impervious backfill in cut-off trench in lieu of sheet piling, and (3) construction of drainage facilities beneath the downstream (landside) toe.

F. SOURCES OF CONSTRUCTION MATERIAL. Five areas, four in Holyoke and one in the Town of West Springfield have been investigated and are considered as potential sources of earth construction materials. These areas including the location and the records of explorations are shown on Plates Nos. 25 and 26. The preferred source of impervious material for the riverside blanket is Borrow Area H in the Town of West Springfield. An alternative source of impervious materials of less suitable quality is located in Borrow Area B in Holyoke. Materials suitable for pervious embankment and backfill constructions are located in Borrow Area C. A very coarse bouldery gravel containing considerable fines occurs in Area D and a gravel of less bouldery content in Area E. Final selection of these borrow areas has been deferred pending future developments as to their availability.

G. <u>CONCLUSIONS AS TO GEOLOGIC FEASIBILITY OF PROPOSED PLAN OF LOCALE.</u> From a geologic point of view the project as planned is feasible, as follows:

<u>a</u>. The overall geologic conditions are favorable. The foundations contain pervious materials in proximity to the river bank but reductions in the quantity of seepage will be affected by installation either of sheet piling for partial depth of the pervious layer at the surface, or an impervious cut-off trench. Control of emergent seepage will be affected by deep drainage facilities.

<u>b</u>. Earth embankment materials of suitable quality are available within economic hauling distance.

APPENDIX III

SOIL DATA AND ANALYSIS

APPENDIX III

SOIL DATA AND ANALYSIS

CONTENTS

APPENDIX III

CONTENTS (Continued)

APPENDIX III. SOIL DATA AND ANALYSIS

A. LABORATORY AND FIELD INVESTIGATION OF SOILS.

1. Classification of Materials. - a. The Providence District has adopted a convenient system of soil classification having standardized terms. In the Providence Soil Classification soils are described by a name, covering general type of soil, plus a grain-size number which latter is a function of position and shape of grain-size curve. Grain-size numbers are divided into 16 classes as shown graphically on Plate No. 27, and described in Table No. 1 on page III-2.

b. Estimates of permeability variations are facilitated by assignment of grain-size numbers, and in compilation of soil profiles for study purposes grain-size numbers are often used alone as an abbreviated notation, in lieu of more complete description recorded in logs of the explorations. Grain-size numbers are determined from results of grain-size tests, but to a major extent such is accomplished from visual examination in which case subscript "v" is included denoting visual classification. Use of double class numbers as (6-4) indicates coarser part of gradation curve lies in class 6 range and finer part in class 4 range - in this case a very uniform medium to fine sand. In contrast, class 4-6 would represent a more variably graded fine sand. In using double class numbers even numbers are never combined with odd numbers.

2. Grain size. - Grain-size curves of samples were obtained by sieve and hydrometer tests run on representative samples for major strata encountered. These materials were classified and grouped into units as shown on soil profile of Plate No. 28. Gradation range for cinders comprising major portion of rubbish fill underlying embankment proper of existing dike is shown on Plate No. 31. Gradation range for underlying natural foundation soils is shown on Plate No. 32. Gradation range for existing embankment is shown on Plate No. 30. Gradation ranges of borrow soils being considered for new embankment are shown on Plates Nos. 33 and 34.

3. Water content and density. - A few natural water contents and densities were determined from short soil cylinders taken as boring drive samples along centerline of existing dike, and are shown on Plate No. 28. However, for most part, these data were assumed to correspond closely to those for Holyoke Dike Project, Hl.3, immediately upstream, for which many borings were made and from which considerable amount of water content and density data was obtained.

4. Permeability. - a. Coefficients of permeability for foundation and embankment materials were determined on remolded samples using de-aired water in most cases. Some of values for

TABLE NO. 1

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PROVIDENCE DISTRICT SOIL CLASSIFICATION

CLASS	DESCRIPTION OF MATERIAL
1	Graded from Gravel to Coarse Sand.– Contains little medium sand.
2	Coarse to Medium Sand.– Contains little gravel and fine sand.
3	Graded from Gravel to Medium Sand.– Contains little fine sand.
4	Medium to Fine Sand.– Contains little coarse sand and coarse silt.
5	Graded from Gravel to Fine Sand.– Contains little coarse silt.
6	Fine Sand to Coarse Silt.– Contains little medium sand and medium silt.
7	Graded from Gravel to Coarse Silt.– Contains little medium silt.
8	Coarse to Medium Silt.– Contains little fine sand and fine silt.
9	Graded from Gravel to Medium Silt.– Contains little fine silt.
10	Medium to Fine Silt.– Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10C	Medium Silt to Coarse Clay.– Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11	Graded from Gravel or Coarse Sand to Fine Silt.– Contains little coarse clay.
12	Fine Silt to Clay.– Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12 C	Clay.– Contains little silt. Possesses behavior characteristics of clay.
13	Graded from Coarse Sand to Clay.– Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13C	Clay.– Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

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borrow area "B" and all values for borrow area "C" were determined with tap water and may not be of as high reliability. Results are summarized in Table No. 2 "Summary of Materials Available," page III-4, and type of water used is indicated for each group shown therein. Quoted values correspond to temperature 10° C (50° F), considered as average ground water temperature.

b. On soil profile given on Plate No. 28 are shown actual laboratory and field test permeability values; estimated numerical permeability values; and visual permeability estimates made during soil classification to assign materials into following permeability groups (at density corresponding to that in natural deposit):

Permeability Group	Coefficient of Permeability, k In units cm/sec x 10^{-4}
Impervious (M)	< 0.1
Random Impervious (RM)	0.1 - 1.0
Random Pervious (RP)	1.0 - 10
Pervious (P)	10 - 500
Very Pervious (VP)	> 500

This is an absolute classification (used for all District sites) and has proven very helpful in studying seepage problems. Permeability grouping of absolute classification does not necessarily correspond to usage grouping at a particular site, where object of latter is to secure a permeability ratio of at least one to ten between different components of embankment section using available soils. As an example, a soil in pervious group (absolute classification) at semi-loose natural density may be in random pervious group when compacted, and because of availability be actually used in pervious section of embankment at a particular site where soils forming adjoining random section of embankment are considerably more impervious RM and M groups. Permeability grouping is generally made on basis of existing natural density for undisturbed foundation soils and for condition of 100% degree of compaction for proposed borrow soils.

5. Consolidation. - No consolidation tests were performed on materials from this site. Settlement observations and consolidation tests performed for other sites in Connecticut River Valley with similar or more compressible soils were available and indicate only minor settlement to be expected for this site. Some settlement of rubbish fill in foundation is expected but it is believed major portion of this has been accomplished by existing dike embankment and attempts to predict such by laboratory tests are not feasible.

6. Shear. - As the general soils of the Connecticut River Valley have been extensively tested, no shear tests were performed on samples of natural foundation materials at this site. However, several of possible borrow sites under consideration have been tested using direct shear method with full drainage. With exception of finer grained glacial tills, all materials are essentially

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Table No. 2

SPRINGDALE DIKE

SUMMARY OF MAJOR MATERIALS REQUIRED AND AVAILABLE

TYPE	MATERIALS REQUIRED: EMBANKMENT MEASURE CU. YDS.	MATERIALS REQUIRED: SHRINKAGE AND LOSS FACTOR	MATERIALS REQUIRED: EXCAVATION MEASURE CU. YDS.	MATERIALS AVAILABLE - EXCAVATION MEASURE: SOURCE	ESTIMATED TOTAL AMOUNT AVAILABLE AND USABLE CU. YDS.	TYPE	CLASS	k x 10^{-4} CM/SEC.	∅	COMPACTION CHARACTERISTICS: w(opt) %	COMPACTION CHARACTERISTICS: D.C.W. pcf	PROV. VIBRATED DENSITY pcf	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Impervious	35,000	1.0	35,000	Borrow Area "H" (W. Springfield)	400,000 +	Glacial Till, compact and cohesive.	7-9v 9v 7-11v 9-11 13-11 11	0.001-0.05	35° (est.)	12.6 - - 13.2 - 13.7	121.8(c) - - 121.5(c) - 118.7(c)	130.7 - - - - -	G = 2.68 - 2.74 Avg. = 2.71
				Borrow Area "B" (a) (Use of this area not planned.)	100,000 +	Glacial Till, compact, extremely variably graded. Deposits of more pervious till occur near surface and irregularly through mass.	3-5 3-7 5-7 5-9 7-9 7-11 9 9-11 11	0.019-0.130 **0.002-0.142 0.023 * 0.00486 - *0.0049-0.0313 * 0.686 *0.0072-0.014 -	- 34°-50' - 40°-35' 33°-30' 38°-53' 42°-15' 34°-05' 33°-30'	- 6.2 - 9.2 10.7 9.0 10.2 9.3 9.3	122.8(c) 129.6(d) - 130.1(b) 126.1(b) 129.9(b) 125.7(b) 127.5(b) 129.0(b)	- - - - - - - - -	G = 2.62 - 2.76 Avg. = 2.70
Random	38,200	0.75	1,000 ±	Required Excavation	1,000 ±	Flood Plain Silt and Sand	4, 6, & 8	3.5-5.5	-	16 (est)	107 (est.)	-	G = 2.65
		0.8	Approx. 47,000	Excavation from existing dike. (Original source, Borrow Area "B".)	Over 47,000	Glacial Till	Same as less impervious soils in Borrow Area "B" (above).						
Pervious	10,500	0.85	12,400	Borrow Area "C"	50,000 ±	Formation composed chiefly of uniform medium to fine sand.	4-2 6-4	* 11.0-70.0 * 1.6	32°-40' 32°-10'	- -	- -	105 (e)	G = 2.68 - 2.73 Avg. = 2.71
				Required Excavation	None	Cinder Rubbish Fill	-	12-150	-	-	-	-	G = 2.33 - 2.56 Avg. = 2.44 To be spoiled.
Topsoil	12,500	1.0	12,500	Foundation Stripping	4,000	-	-	-	-	-	-	-	To be stockpiled until required for topsoiling dike.
				Local Borrow	To be developed	-	-	-	-	-	-	-	Some probably available from Area "H" (West Springfield).

NOTES: * Tap water used (all others de-aired water except **).
** Both tap water and de-aired water used.
(a) Only the more impervious of soils encountered in Borrow Area "B" are usable in impervious blanket.
(b) Except where covered by special note, compaction tests run in 4 in. diameter cylinder by standard Proctor method and theoretical correction applied for % screened out.
(c) Compaction test run in 6 in. diameter cylinder by method comparable to standard Proctor method (56 blows per layer with 5.5# hammer dropping 12 in.). Stones to 2 in. included and no correction applied for % screened out. Method considered more representative of actual field results than standard Proctor method.
(d) Compaction tests run by both of methods given in notes (b) and (c).
(e) Maximum density obtained by compacting dry in 4 in. Proctor cylinder, 4 layers, 35 blows per layer.

cohesionless. Average values for some of the construction materials are shown in Table No. 2, "Summary of Materials Available," page III-4.

7. Compaction. - a. A considerable number of early compaction tests on borrow area "B" glacial till were performed by standard Proctor method, in 4 inch cylinder using 25 blows per layer with 5.5 lbs. hammer dropped 12 inches. All other compaction tests on samples of impervious and random materials were run in a 6-inch diameter cylinder; since material as coarse as 2 inches could be used, results are considered more reliable. The number of blows was regulated so that results were the same as those produced by standard Proctor compaction test in 4-inch cylinder. Typical compaction curves are shown on Plate No. 35. Compaction properties are summarized in Table No. 2, "Summary of Materials Available," page III-4; type of test performed is indicated therein.

b. In tests on borrow area "C" cohesionless soils which were performed several years ago, feasible maximum density was approximated by compacting dry soil in standard Proctor cylinder, in 4 layers, using 35 blows per layer with standard 5.5 lb. Proctor hammer dropping 12 inches.

c. For cohesionless materials from more recently explored areas feasible maximum density was determined by means of the Providence Vibrated Density Test in which a vertical static load of 800 lbs. is maintained by a calibrated spring on a sample in a 6-inch cylinder and compaction obtained by means of vibrating with (60-100) hammer blows until no readily measurable further compaction occurs. The advantages of this test are that it produces compaction results on cohesionless materials more reasonably equal to those easily produced in the field, and that it does not break down the soil grains, as frequently occurs with an impact type of test on cohesionless soils.

8. Specific gravity tests were run on occasional samples. Typical values are shown on Table No. 2, "Summary of Materials Required and Available," page III-4.

B. FOUNDATION CONDITIONS. - 1. Embankment of Existing Dike. - a. The City of Holyoke constructed an earth dike in 1928 to about elevation 68± along the line of the present dike. The available data indicate that this dike was constructed directly on top of the old rubbish fill without any effort to provide a cut-off below dike. It has been verbally reported that embankment was borrowed from silty gravel borrow pits a short distance west of Holyoke Poor Farm (of which material in borrow areas "D" and "E" (see Plate No. 25) are representative). However, none of borings in existing embankment encountered a material of this description.

b. Late in 1936 the dike was raised by placing random impervious glacial till from Cherry Street Borrow Area "B" on top and on landside of the then existing dike as shown on Plate No. 29. A City of Holyoke drawing of this construction shows a landside cut-off trench on the southerly reach of dike in the position indicated on latter Plate.

(1) City employees report that the 1936 dike construction was done without benefit of line or grade information and that cut-off trench was excavated with a power shovel to an estimated depth of 4 to 5 ft deep. Since only general directions were given to construction forces as to where trench should be dug, position of it is uncertain and is apt to vary with respect to centerline. A reasonably probable position is shown on Plate No. 29.

(2) The raising and widening of the dike was done without any compaction except from trucks hauling fill and with no attempt to control the moisture content of fill. Because the method of compaction of the 1928 construction is not known and this addition to dike is known to be loose, it must be assumed that the entire existing dike is in a relatively loose condition.

2. Rubbish fill. - The ground upon which existing Springdale Dike is located was used for many years as a dumping ground for miscellaneous debris from factories in City of Holyoke. Most of this dumping was done prior to 1905 as a map in possession of Holyoke City Engineer of that date shows ground surface along present dike centerline approximately same as that now existing behind dike. Soil profile, Plate No. 28, shows occurrence of this material in foundation.

a. Practically the entire existing dike is underlain by this miscellaneous fill. It consists principally of cinders, but contains also hard coal ashes, brick, tin cans, wood, coal and other rubbish. Depth of this deposit between top of original ground and bottom surface of dike fill varies from 0 to 25 ft along dike centerline and averages at least 15 ft. Because of the natural downward slope of the original ground in direction of the river, it is likely that depths in excess of 25 ft may occur under riverside toe of existing dike.

b. Based on permeability tests of cinders, average permeability coefficient of 120×10^{-4} cm/sec has been adopted for rubbish fill. This is believed conservative. However, permeability of rubbish fill is believed subject to considerable variation because of uncertainties as to nature of fill between borings.

3. Natural foundation soils. - a. Upper part of the natural foundation soils (immediately under rubbish fill) consists of 8 to 30 ft of gray, Classes 4, 6-4, 6 and 8, fine sand and silty sand - flood plain deposit of same type as found generally

elsewhere on the Connecticut River. Average permeability coefficient from remolded samples is estimated at 15×10^{-4} cm/sec at natural density.

b. Below the above stratum is 0 to 15 ft of same type of sand, though slightly coarser, and distinguished by a relatively high percentage of wood fragments and organic particles not present in overlying material. In places this sand is dark and odorous. Since this stratum is at approximately same elevation as river bottom in present channel, it is evident the channel at one time must have included area of existing Springdale Dike, either because of a greater channel width or because of a different channel alignment. However, this is believed to have been of the order of 75 or 100 or more years ago because of the considerable deposit of overlying sand and silty sand (average of 15 ft ±) accumulated before dumping of rubbish fill was started. Permeability of this stratum is considered same as above stratum - organic content tending to balance slightly coarser gradation.

c. Next underlying, under a cover of 25 to 40 feet, is a deposit of brownish-gray gravel and sand, principally gravel. Permeability of this layer is variable, but composite value for disturbed samples is estimated at 50×10^{-4} cm/sec at natural density.

d. Strata below this, at approximately 40 to 50 ft depth, show distinctly different color from overlying layers and have reddish color typical of many Connecticut Valley soils. Gradations range from coarse gravel to extremely uniform coarse silt. Permeabilities range from 1 to 100×10^{-4} cm/sec.

4. Near failure of existing dike in 1938 flood. - a. Conditions observed. - During the flood in September 1938 the Springdale Dike barely escaped a serious failure, which might have occurred with a higher flood level or one which dropped less rapidly after the peak or if accidental ponding had not occurred behind the dike. In the course of repairs to the Berkshire Street sewer (prior to 1938 flood) a cross connection had been made between Berkshire Street and Front Street sewers so as to divert Berkshire Street flow into Front Street sewer during this work. When repairs were completed, the connection was not removed or plugged. Therefore, when Connecticut River rose in the Berkshire Street sewer it ran through this cross connection into the Front Street sewer to the existing pumping station, and also poured into the Springdale area through various manholes along its path. Stopping of the pumps by electric failure was probably very fortunate as it resulted in building up a tailwater pool from seepage and inadvertent diversion of Berkshire Street sewer and thus lowered the effective head.

(1) The ponding behind the dike resulting from failure of the pumps occurred to a maximum height of approximately

elevation 61. This prevented observation of very bottom of dike and ground surface immediately to landside. However, no evidence of boils or excessive seepage was noted except at one point where heavy seepage (or boil) is reported to have developed directly at toe and extending 5 ft up dike which it was necessary to sand bag over an area 25 ft long by 20 ft wide. Several places were observed where dike landside slope had softened and sloughed down for height of 5 ft above toe but only slight seepage was evident above tailwater formed by the pond in the park.

(2) A continuous longitudinal crack was visible for about 1100 ft along approximate centerline of southerly part of dike approximately from Station 28+65 to Station 39+65 and generally varying in width from 1/4 in. to 3 or 4 in. For a stretch of 200 ft at approximately Station 33+00 to Station 35+00 it was 8 to 10 in. wide. In one or two places water could be seen in this crack at a depth slightly over 5 ft which was only slightly below the level of the water in the river. Seepage line must, therefore, have developed on a very flat slope as shown on Plate No. 29. At places up to 1 in. of settlement of portion of the dike on landside of centerline crack was observed. Estimated planes of slippage of materials on basis of surface evidence are shown on Plate No. 29.

b. Cause of failure. - Two possible explanations have been suggested for the near failure during 1938 flood, as follows:

(1) The cracking along centerline of dike may have been due to settlement of the fill placed in 1936 which had been given very little compaction. This is a reasonable explanation and undoubtedly contributed to the occurrence of the centerline crack.

(2) A second explanation is that the centerline crack and slight settlement of dike top on landside of crack were evidences of an incipient deeper-seated slide. When underseepage emerges at a landside toe, with upward seepage forces countering downward force of soil weight, a tendency toward flotation, and a consequent considerable reduction in the inter-granular forces creating shear strength is produced. Such reduction in toe support favors a slide of landside slope - in this case through dike material of relatively low shear strength because of low degree of compaction.

(a) To a marked degree the relatively impervious material on the landside part of dike section and partial cut-off reported to have been installed in the 1936 dike would accentuate this by creating nearly full river level hydrostatic pressure immediately to riverside of landside impervious - shown to have occurred by water level observed in the centerline crack. Such unduly large landside seepage pressure would increase overturning forces acting on landside slope, already weakened by loss of toe support. It would also cause unusually high seepage forces in zone of seepage emergence on and near the toe of slope (concentrated at tail water) and thus contribute to occurrence of secondary sloughs - such being most pronounced where landside cut-off through the uppermost stratum of pervious cinder fill was most nearly complete.

(3) Data which are significant with respect to this second explanation are as follows:

(a) Cut-off trench is reported to have been installed between Station 27+00 and Station 45+00. The dike was cracked from Station 28+65 to Station 39+65, a good agreement.

(b) As shown on Profile, Plate No. 28, thickness of relatively pervious rubbish fill is thinnest in cracked portion of dike, tending to permit fairly complete cut-off by a trench dug as shown on Plate No. 29. Condition is made more critical by fact that auger boring FA-50 (near landside toe at Station 32+95) showed only 2.3 ft of rubbish fill over relatively impervious sand and silt, indicating fill is thinner at landside toe than at centerline.

(c) The appearance of water in the crack at approximately the same elevation as river indicates that practically full hydrostatic head existed at midpoint of dike and that this head was therefore being dissipated principally on landside of dike.

(d) As indicated on Plate No. 28, the section of dike where worst cracking occurred is near point where lowest ground occurs immediately at landside toe. Consequently higher head differential was available in this area to produce greater destructive seepage forces.

C. <u>CONTROL OF SEEPAGE</u>. - 1. <u>Cut-off</u>. - <u>a</u>. Presence of pervious rubbish fill in foundation requires a cut-off because of its uncertain and probably variable nature. On basis of present information this has been designed as a sheet pile cut-off over entire length of dike to be driven through the rubbish fill and a short distance into the underlying sands and silts. Tentative location of bottom of sheet piling is shown on soil profile along existing dike, Plate No. 28, as planned to cut through the rubbish fill which old surveys indicate is probably slightly deeper on line of the sheet piling than on centerline of existing dike where borings were taken.

<u>b</u>. Further borings have been made on the revised dike alignment at southerly end. Final results are not available at time of this report but preliminary information indicates fill under new alignment may be shallower than at present borings on centerline existing dike. When final boring results are obtained, it may be found desirable to use an excavated cut-off trench through rubbish

fill in portions of this southerly reach of dike in manner indicated on Plate No. 36. For reasonable depths such a cut-off may prove to be more economical and will be more positive than sheet piling.

2. Toe drain. - In order to intercept the anticipated considerable seepage flow through rubbish fill which will pass through and under sheet pile cut-off a continuous landside toe trench will be excavated well into pervious rubbish fill as shown on Plate No. 36, to a minimum depth of 4 ft below ground surface. This will be backfilled with screened gravel designed for filter action against surrounding soils and of relatively much higher permeability. At places trench will be as much as 10 ft deep. For simplicity and economy a continuous trench was selected in preference to a shallower trench with occasional deeper drain extension pits. Where trench is excavated in finer flood plain silts or in fine coal ashes, an intermediate layer of sand will be placed between the foundation soil and the screened gravel to prevent clogging by these finer soils. Open-joint and perforated pipe laid in the filter gravel will bleed off seepage water into drainage system leading to pumping station thus avoiding erosion due to seepage emergence from toe.

3. Gravel toe. - In part of southerly reach of dike it is not practical to lay drain pipe at appreciable depth below existing ground surface because of a dip in natural ground profile. As a result some seepage emergence on land-side of dike is expected with the possibility of ponding in the low area in the vicinity of Station 36 during heavy rainfall. In order to provide safety against any possible seepage erosion a gravel toe will be installed as shown on Plate No. 36. This will be composed of coarse bank-run gravel not readily moved by seepage. It will have equal or higher permeability than adjacent horizontal pervious blanket.

4. Seepage estimate for new dike. - a. Assumptions. - To estimate rate of seepage which will result in reconstructed dike, flow nets were drawn using following assumptions:

(1) River level at elevation 73 - approximately top of concrete wall at upstream end of dike.

(2) Permeability of rubbish fill equals 120×10^{-4} cm/sec.

(3) Permeability of underlying natural soils equals 30×10^{-4} cm/sec.

(4) Horizontal permeability is 4 times that in vertical direction so that transformation factor equals

$$\sqrt{k_v/k_h} = \sqrt{1/4} = 1/2$$

(5) Sheet piling is 50% efficient - i.e., leakage through actual piling amounts to 1/2 of seepage which would be cut-off by ideal piling.

(6) Flow through the random impervious to impervious dike is negligible.

b. Results. - (1) Flow nets are shown on Plates Nos. 38 and 39 for cases of deep cinder deposit with sheet pile cut-off and of no rubbish fill with trench cut-off. A flow net for seepage conditions in 1938 Flood is also shown on Plate No. 37. Using flow nets for case of sheet pile cut-off and for 1938 conditions, rate of seepage has been computed for proposed dike as follows:

FLOW NET RESULTS

CONDITION	PLATE NO.	SEEPAGE, CFS
No piling	37	$\frac{19}{5} \times 3.6 = 13.6$
With piling 100% Impervious	39	5.6
Seepage Cut Off by Piling		8.0

Seepage Estimate Adopted

With piling 100% impervious	5.6 cfs
Leakage through piling (assumed 1/2 of that cut off by 100% impervious piling)	4.0 cfs
Total seepage	9.6 cfs

Allowance for leakage through the piling is the most uncertain factor and has been taken as 50% of the difference in seepage with no piling and with ideal piling. That very substantial leakage has occurred through piling has been shown by recent observations on U.S.E.D. structures but quantitative data have not yet been obtained.

(2) Check on seepage was available from observations in 1938 flood as will be described below. As result of this check a value of 2 was considered a satisfactory design factor and seepage estimate for use in pipe and pumping computations was therefore computed as 9.6 x 2 = 19 cfs. (Earlier value of 18 cfs from less refined flow nets appears in hydrology appendix of this report, but difference is not significant within accuracy of seepage estimate.)

c. No attempt has been made to divide dike into sections for individual seepage analysis because of the many uncertainties as to depth and composition of man-made rubbish fill and because higher elevation of drainage lines at northerly end of dike will tend to counter greater depth of cinders in that area and thus tend to balance seepage rate per station into drains. At southerly end of dike drainage lines will be at lower elevation but thickness of rubbish fill is appreciably less. For design purposes seepage rate per station has been assumed uniform pending more detailed foundation information.

5. <u>1938 seepage from observations.</u>

a. From records of an observer during 1938 flood, the two existing pumps at the dike, with capacity of 25 cfs each, were able to draw down pool behind dike by only one inch during the night following peak flood height. Assuming pumping rate at 50 cfs this showed average inflow during that night to be approximately 47 cfs, part of which was from sewer inflow and part from seepage. Average differential head acting on dike during that period was 5 ft. According to observers, heavy inflow occurred from Front Street sewer due to inadvertent cross connection with Berkshire Street sewer, which is a pressure conduit and which was open directly to Connecticut River. This flow was sufficient to overflow through manholes and produce surface flow of 2 to 3 cfs on Main Street. Flow through pipes of Front Street sewer itself under this head is computed as approximately 36 cfs, controlled by two 18 in. diameter pipes at point where sewer crosses under Main Street. Thus total sewer inflow including overflow onto streets was approximately 39 cfs.

Total Inflow	= 47 cfs	
Inflow due to sewers	= 39 cfs	
Inflow due to rainfall run-off	= 0 cfs	(no rain at time)
Difference	= 8 cfs	= inflow due to seepage.

b. It is unlikely pumps could operate above their rated total capacity of 50 cfs but they might pump less. Assuming sewer inflow same as has been computed, this would give a lower computed seepage.

c. Sewer flow might have been more than has been computed but as long as flow was emerging from manholes quantity could not have been appreciably less. If sewers contributed more, computed seepage would again be reduced.

d. It thus appears that actual seepage rate in 1938 flood at the river stage for which computation has been made might be smaller than 8 cfs but was probably not more.

6. <u>1938 seepage from flow net.</u>

a. From flow net drawn for 1938 conditions with no sheet piling, shown on Plate No. 37, and using the same permeability values adopted for proposed dike enlargement, a seepage rate of 4 cfs was obtained for an average head of 5 ft. This value contains an allowance of 0.4 cfs for seepage through dike itself, assumed impervious in flow net. Agreement between this value and the maximum possible value of 8 cfs computed from observations in 1938 flood is considered fairly good.

b. Since the maximum value of 8 cfs computed from actual flood observations is twice the 4 cfs computed from flow net analysis it is unlikely that actual seepage for proposed dike enlargement will be more than twice seepage estimate of 9.6 cfs computed from flow nets as described above and justifies adoption of design factor of 2 for use in computation of drainage lines and pumping equipment.

D. EMBANKMENT CROSS-SECTIONS. - Embankment sections have been designed to provide effective drawdown of line of seepage by means of permeability transitions through dike. In most sections pervious rubbish fill in foundation will attract seepage on drawdown and thus prevent reversal of seepage from impervious blanket on drawdown which would otherwise tend to cause slides on riverside slope. Plate No. 36 shows permeability changes through embankment.

1. Northerly dike section. - Between approximately Stations 8+84 and 27+00 dike will be enlarged approximately on present alignment. Existing dike is believed in relatively loose condition and soils are somewhat variable but generally random impervious. To add stability and provide the desired permeability transitions, an impervious blanket of best available material will be installed on riverside face and a good pervious blanket will be placed on lower part of landside face.

2. Southerly dike section. - Between approximately Stations 27+00 and 45+68 dike will be reconstructed on new alignment for reasons given in body of this report. The uncertain and probably variable random materials in existing dike will be used to form a maximum size random section. More pervious material in random section will be placed to landside and more impervious to riverside, as far as possible. A good impervious blanket and a thin horizontal drainage blanket will insure adequate drawdown of line of seepage.

E. SELECTION OF MATERIAL SOURCES. - Major volume of materials required in proposed dike will consist of random from required excavation and from borrow from existing dike embankment. Required additional pervious and impervious materials will be in relatively small amount and will be borrowed from areas off site. Volumes of materials and soil properties are given on Table No. 2, "Summary of Materials Required and Available," page III-4. Locations of borrow areas are shown on Plates Nos. 25 and 26.

1. Pervious borrow. - Several sources were investigated for pervious borrow but area "C" was chosen as being nearest to site and of best quality. Areas "D" and "E", which were also investigated, consisted of silty gravel of insufficiently high permeability to attract seepage from pervious foundation, and involved longer hauls.

a. Area "C" was explored several years ago. Material consists of very uniform medium to fine sand, chiefly Class 4-2, with average permeability coefficient (using tap water) = 35×10^{-4} cm/sec in compacted state. Higher permeability would probably result if tests were run under present day procedure using de-aired water.

b. Borrow area "C" is suitable for use in landside pervious section of dike and as a second filter layer where required between fine foundation soils and screened filter gravel in drain trench.

2. Impervious borrow. - Considerable search was made for suitable impervious within reasonable hauling distance of the site. Two possible sources were found and these have been investigated in some detail. Primary requirement of impervious borrow is for material of quite low permeability value, sufficient to produce appreciable permeability transition between impervious blanket and central random section of moderately impervious material from existing dike.

a. Area "H" West Springfield. - (1) This area is proposed as a source of impervious material for both the Springdale Dike and the nearby Riverdale Dike. The length of haul to the Springdale Dike is approximately 3-3/4 miles.

(2) Material consists of a compact cohesive glacial till, Classes 9, 11, and 13, which has high shearing strength and is thus well suited to blanket construction. Natural water content is at, or just below, optimum water content, which will facilitate compaction. At some places in this area the desired cohesive till is overlaid by more pervious sandy till and by uniform fine silt. The deposit is also slightly spotty. Thus some random will be obtained in excavating for impervious. Such random may be used for Riverdale Dike in West Springfield or may be side cast. Soil profiles are shown on Plate No. 40.

(3) At least a part of required topsoil borrow can be obtained from stripping in area "H".

b. Area "B" Holyoke. - (1) Detailed investigations have been made in this area which is located on Cherry Street in Holyoke, Massachusetts. Area is owned by the City of Holyoke and would, therefore, be quite convenient to use. Haul by various routes is from 2-1/2 to 3 miles. Soil profiles are shown on Plate No. 41.

(2) Area has been considerably explored over a period of several years. Material consists principally of extremely variably graded compact glacial till, varying from sandy to cohesive. Area is very spotty and in some places contains so much coarse material that when excavated and recompacted fines are not available to fill all voids. Most of available permeability data on this area were obtained several years ago using tap water, and results are considered too low because voids became clogged with air.

(3) Since this borrow area was used for construction of major portion of existing dike and as latter material will form random section of proposed dike, area "B" could not be used for impervious unless considerably better material could be located in the area than has thus far been excavated. Borings indicate sufficient material may possibly be available by deeper excavation in the hillside. However, it is estimated that 1 cubic yard would have to be excavated and sidecast for every 3 cubic yards of suitable material obtained. Since approximately 35,000 cubic yards of impervious will be required for proposed dike, approximately 12,000 cubic yards of unsuitable material would have to be excavated and sidecast in pit. Since ample random is available from existing dike, none of this sidecast material could be used in random section of dike.

(4) It has also been reported that following borrow operations in this pit in 1936, slopes were carefully smoothed under a W.P.A. project, to remove the scar on landscape, presumably since area is within edge of a good residential district. Another careful trimming would, therefore, be required following completion of any further excavation, and would require re-handling of a considerable portion of the estimated 12,000 cubic yards of sidecast material.

c. Comparison of impervious borrow areas. - (1) Even with much selection borrow area "B" impervious till is inferior to that from "H". Also considerable extra excavation is necessary to obtain the required quantity of suitable soil from area "B".

(2) Total costs of areas "H" and "B" per cubic yard delivered to site have been computed as being approximately the same, if the pits are only brought to a relatively smooth surface at end of job and topsoil bulldozed back. If necessary to dress up area "B" slightly better, then total cost per cubic yard from "B" would be greater.

(3) Since there is little choice between areas on a cost basis, area "H" has been chosen in preference to area "B" on basis of superior material. Use of area "H" will involve slightly less cost to the Government and slightly more to the City of Holyoke, the latter being required to purchase the borrow in West Springfield.

(4) Probable permeability values obtained by use of area "H" are shown on sections on Plate No. 36, which indicates transition in permeability between different components of dike embankment.

3. Miscellaneous materials. - Screened filter gravel, bank run gravel, roadway gravel, topsoil and sod are available from numerous sources within a radius not exceeding 10 miles.

F. <u>FOUNDATION CONDITIONS AT PUMPING STATION</u>. - 1. Foundation conditions at proposed new pumping station are shown on Plate No. 28. Based on borings in existing embankment the station will be founded in medium to fine sand and coarse silt flood plain deposits, Classes 4 and 6. Approximately 8 or 10 feet below bottom of pump house foundation is a layer of silty gravel, Classes 5 and 7, approximately 15 ft thick. Underlying latter is at least 15 to 20 ft of very uniform medium sand, Class 4.

2. Foundation soils have more than ample bearing capacity for any anticipated loads.

3. By exercising care in control of ground water during excavation so that foundation soils are not loosened by upward seepage flow, settlement of structure should be negligible, on basis of results with similar structures already constructed on similar or poorer soils.

APPENDIX IV

HYDRAULIC DESIGN

APPENDIX IV

HYDRAULIC DESIGN

C O N T E N T S

APPENDIX IV. HYDRAULIC DESIGN

A. DESIGN FLOOD. The design flood on which the dike grade is based is the maximum predicted flood reduced by the 20 reservoirs included in the Comprehensive Plan for flood control of the Connecticut River. The determination of the maximum predicted flood is discussed in Appendix 1 of "Report of Survey and Comprehensive Plan for Flood Control of the Connecticut River Valley," dated 20 March 1937. It has a peak discharge at Springfield of 318,000 c.f.s., approximately 13 percent greater than the maximum flood of record which occurred in March 1936 and which had peak discharges of 281,000 c.f.s. at Springfield and 253,000 c.f.s. at Springdale.

As a result of the September 1938 flood the maximum design flood was revised upward to peak discharges of 417,500 c.f.s. at Springfield and 356,000 c.f.s. at Springdale (Holyoke).

B. DESIGN GRADE AND FREEBOARD. The survey report proposed (1) a uniform freeboard of 3 feet for both concrete walls and earth embankment above the design flood as modified by the operation of the 20 reservoirs of the Comprehensive Plan, or (2) a freeboard of at least 1 foot above the March 1936 flood elevation. The higher of these criteria established the Report grade. The Board of Engineers for Rivers and Harbors recommended that, since the entire reservoir plan might not be effective for some time, an additional freeboard of 2 feet should be provided for earth dikes.

As a result of the revision of the maximum design flood following the September 1938 flood experience, higher dike grades were set up based on the new design flood modified by 20 reservoirs. Subsequently it was decided that maximum flood protection could better be provided by additional reservoirs than by higher dikes. Additional reservoirs combined with the original 20 or equivalent, would afford stage reduction to the same safe point that was established originally. Therefore the original design grade has been retained and is consistent with the grades to which other local protection works in the system have been constructed under previous contract.

The following table lists the adopted grades for the top of the dike at indicated stations. Grades are straight lines between the stations shown. For comparison, the table lists the discharges and stages for the design flood modified by reservoirs and for the maximum flood of record in March 1936.

TABLE NO. 1

DESIGN GRADES

Location	Upper End	Lower End
Design grade for earth dike, feet M.S.L.	75.2	74.5
March 1936 flood peak, c.f.s.	253,000	253,000
March 1936 flood stage, feet M.S.L.	72.4 approximately	
Modified design flood peak, c.f.s.	218,000	218,000
Modified design flood stage, feet M.S.L.	70.1	69.5

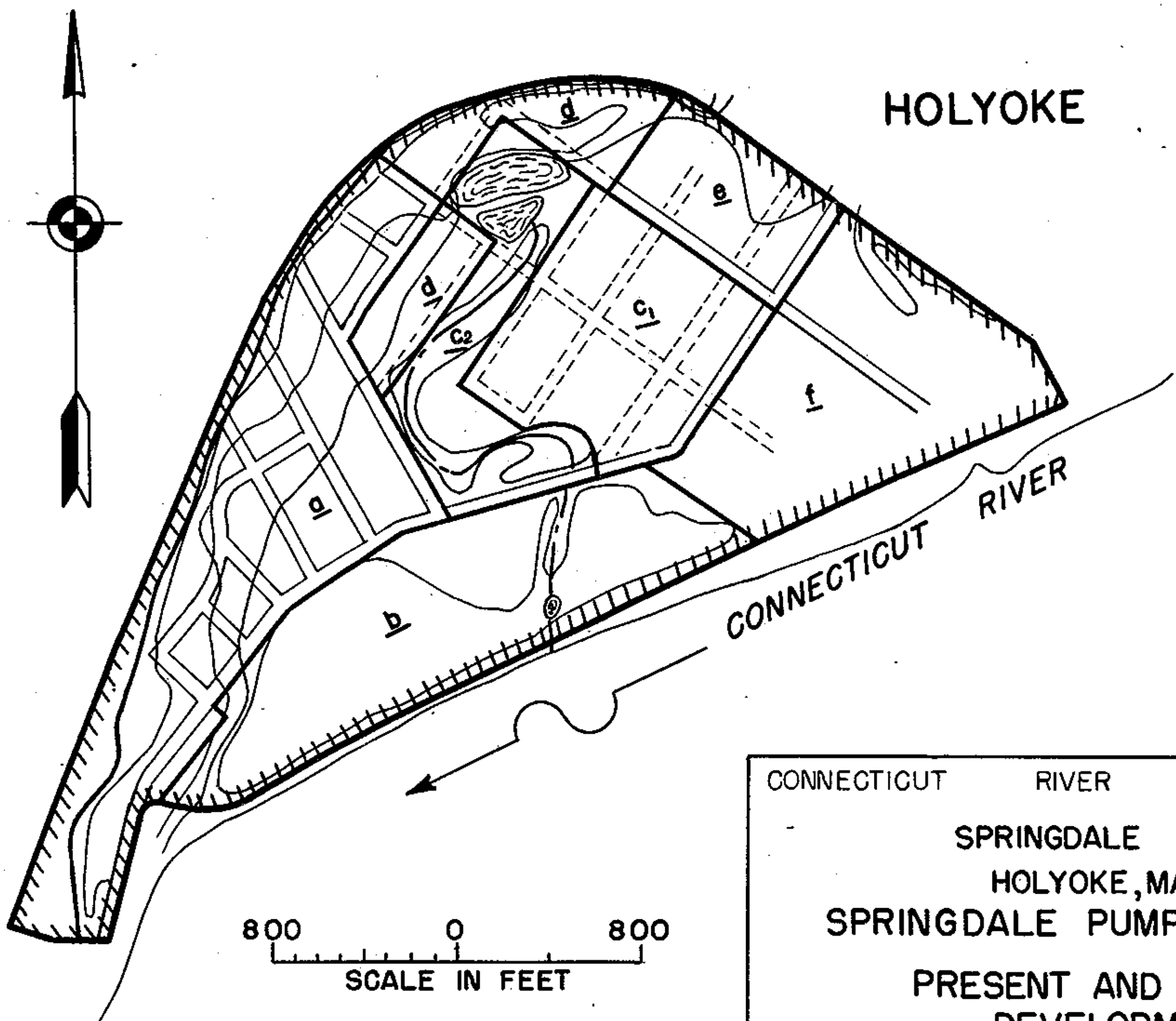
C. PUMPING STATION. - 1. Hydrology. (See Appendix I for the hydrology report).

2. Discharge conduit. Since the discharge conduit will convey the total combined flow at all river stages, the selection of size was based largely upon the discharge requirements of gravity flow at low river stages. With a design total discharge of 86 c.f.s. at a Connecticut River stage of El. 47.8 as shown on Plate No. 7, Envelope Curves - Total Discharge, Future Development, a 42-inch diameter conduit will carry the flow at a velocity of 8.9 f.p.s. and a slope of energy gradient of 0.0070. Dry weather flow of 1.6 c.f.s. will be carried at a velocity of 2.3 f.p.s.

3. Collector drain. The main collector drain to the suction well of the pumping station will be 27-inch diameter and is designed to carry 21 c.f.s. with the Connecticut River at top of dike. The velocity will be 5.1 f.p.s. with a slope of 0.0042.

PLATES

H.R. of H.I. 4a



CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
HOLYOKE, MASS.

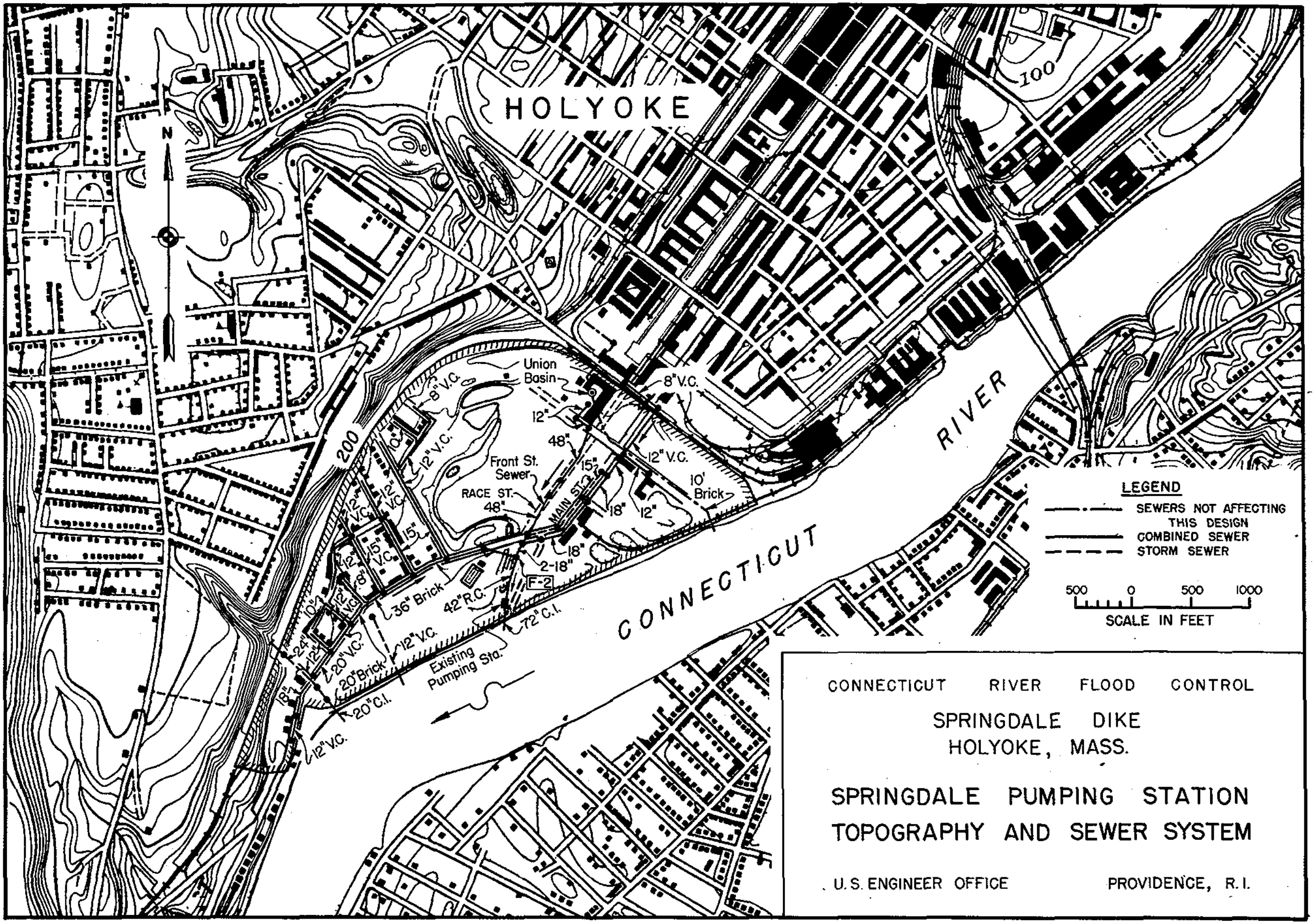
SPRINGDALE PUMPING STATION

PRESENT AND FUTURE DEVELOPMENT

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

PLATE NO. I

HR of HI. 4a



CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
HOLYOKE, MASS.

SPRINGDALE PUMPING STATION
TOPOGRAPHY AND SEWER SYSTEM

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

PLATE NO. 2

H.R. of HI. 40

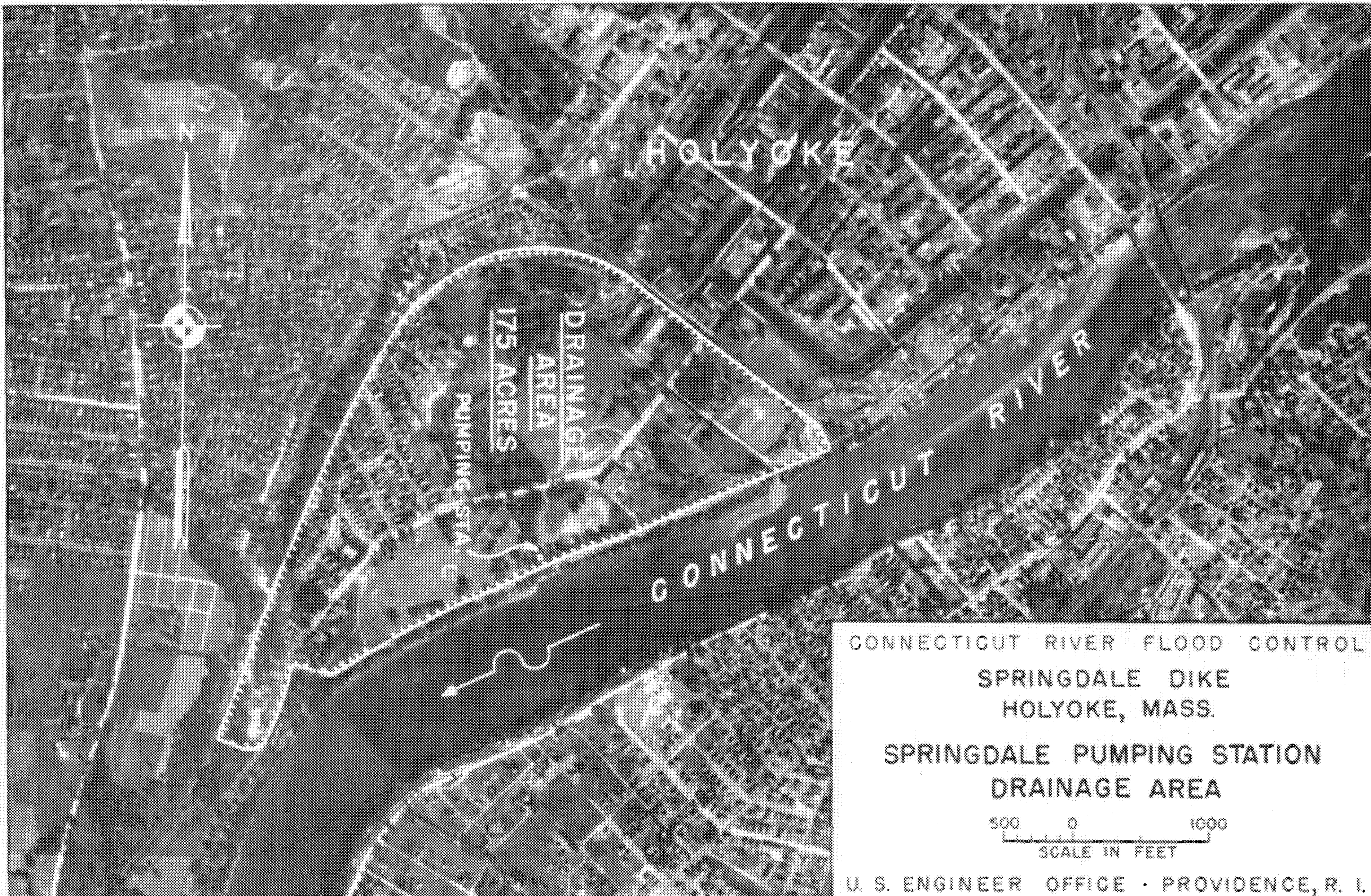
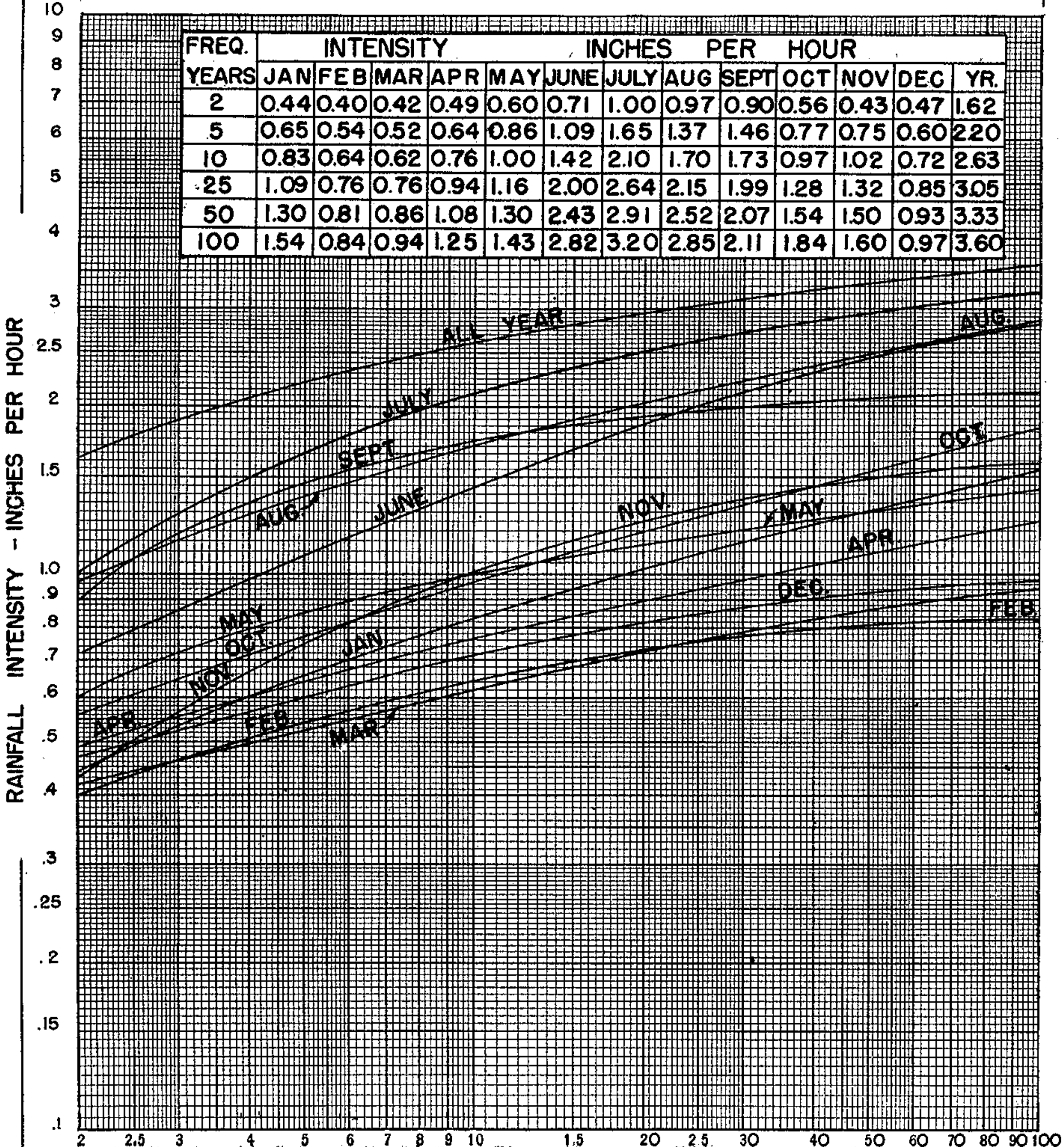


PLATE NO. 3

FREQ.	INTENSITY					INCHES PER HOUR							
YEARS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YR.
2	0.44	0.40	0.42	0.49	0.60	0.71	1.00	0.97	0.90	0.56	0.43	0.47	1.62
5	0.65	0.54	0.52	0.64	0.86	1.09	1.65	1.37	1.46	0.77	0.75	0.60	2.20
10	0.83	0.64	0.62	0.76	1.00	1.42	2.10	1.70	1.73	0.97	1.02	0.72	2.63
25	1.09	0.76	0.76	0.94	1.16	2.00	2.64	2.15	1.99	1.28	1.32	0.85	3.05
50	1.30	0.81	0.86	1.08	1.30	2.43	2.91	2.52	2.07	1.54	1.50	0.93	3.33
100	1.54	0.84	0.94	1.25	1.43	2.82	3.20	2.85	2.11	1.84	1.60	0.97	3.60



FREQUENCY YEARS-30 MINUTE RAINFALL 1905-1944 PROVIDENCE, R.I.

CONNECTICUT RIVER FLOOD CONTROL

HOLYOKE, MASS.

SPRINGDALE PUMPING STATION

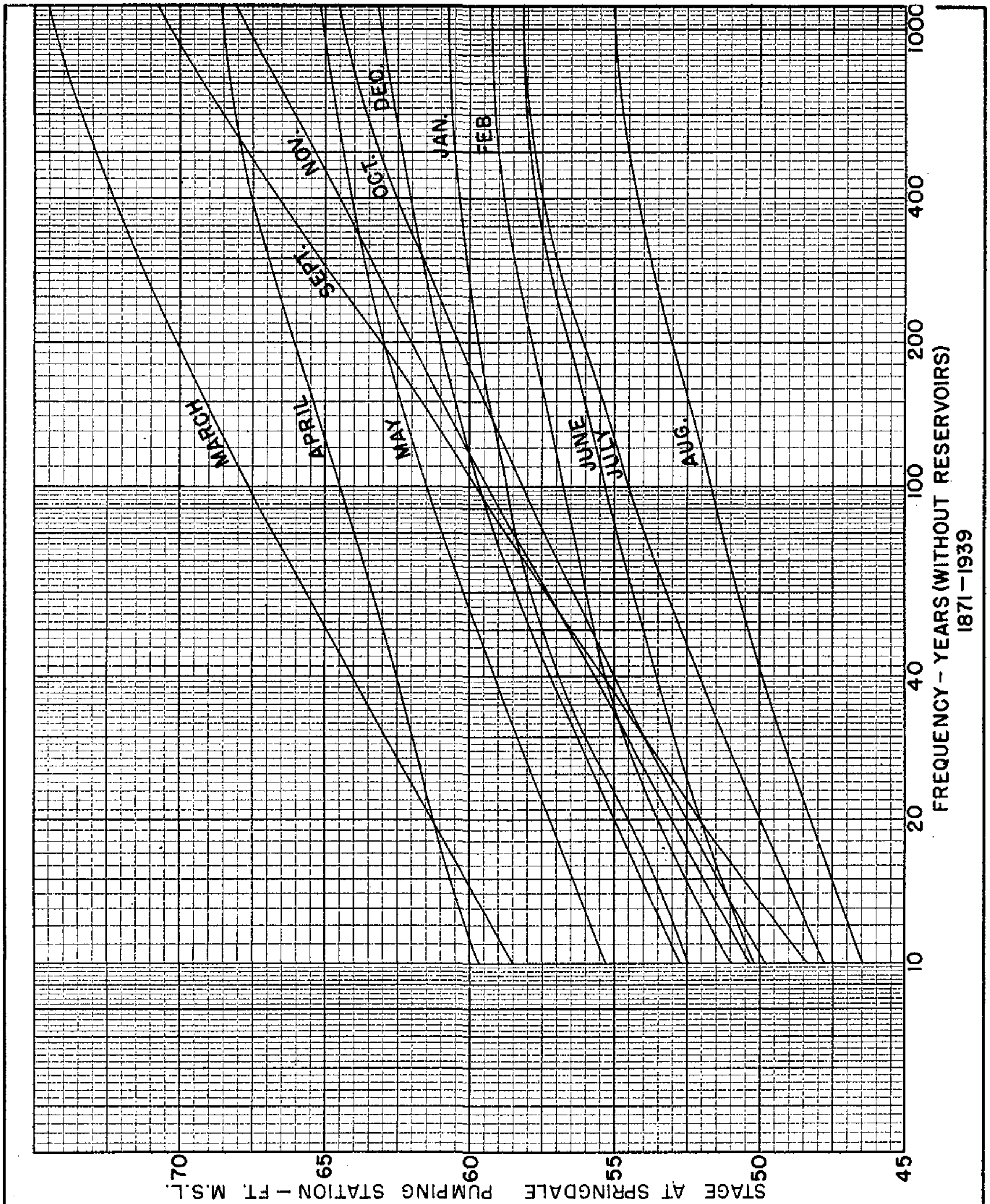
INTENSITY - FREQUENCY CURVES

30 MINUTE RAINFALL

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

HR. of H1.4a

PLATE NO. 4



CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

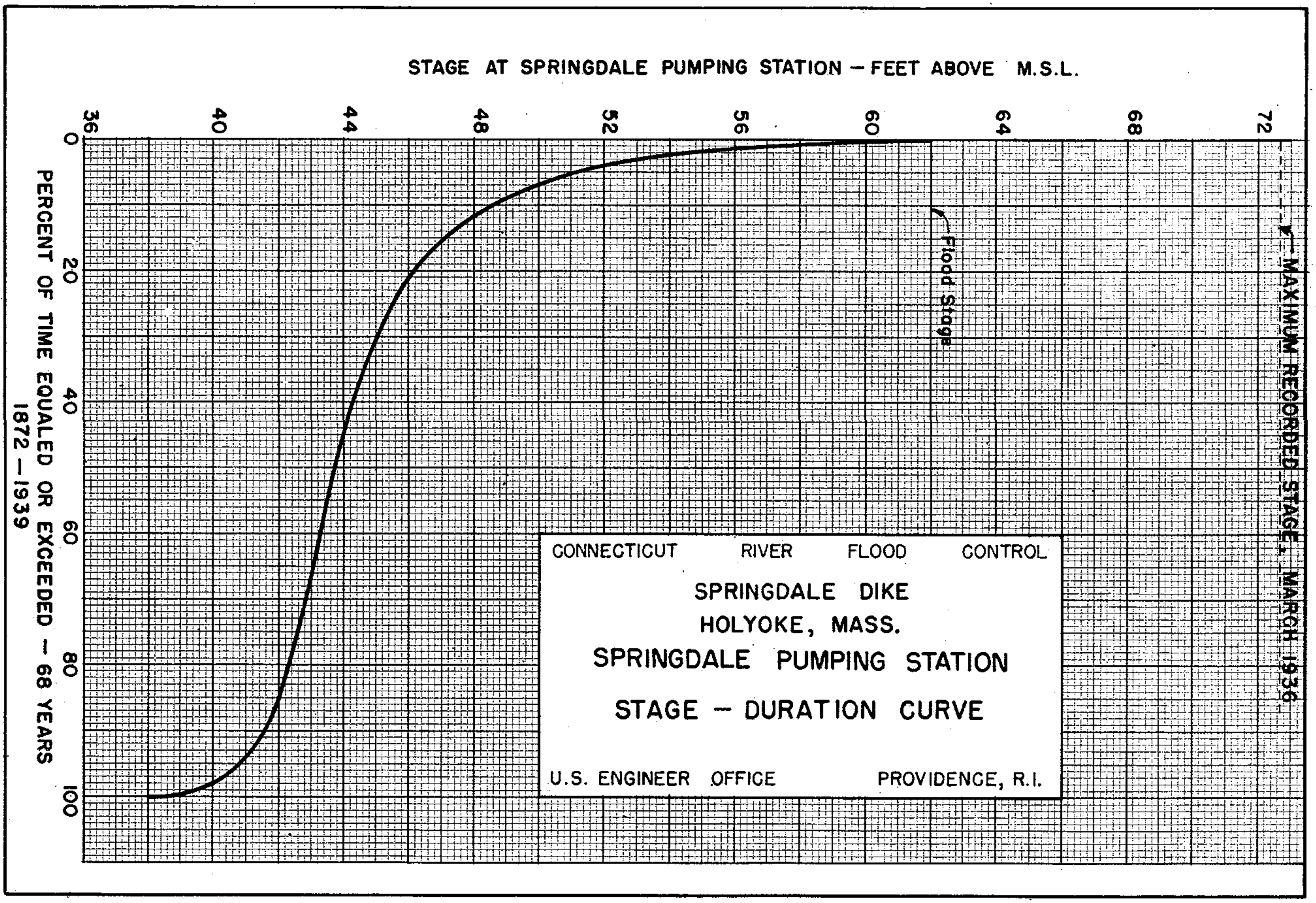
HOLYOKE, MASS.

SPRINGDALE PUMPING STATION

STAGE-FREQUENCY CURVES

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

H.R. of Hl. 4a



CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
HOLYOKE, MASS.
SPRINGDALE PUMPING STATION
STAGE — DURATION CURVE

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

PLATE NO. 6

H.R. of Hl. 4a

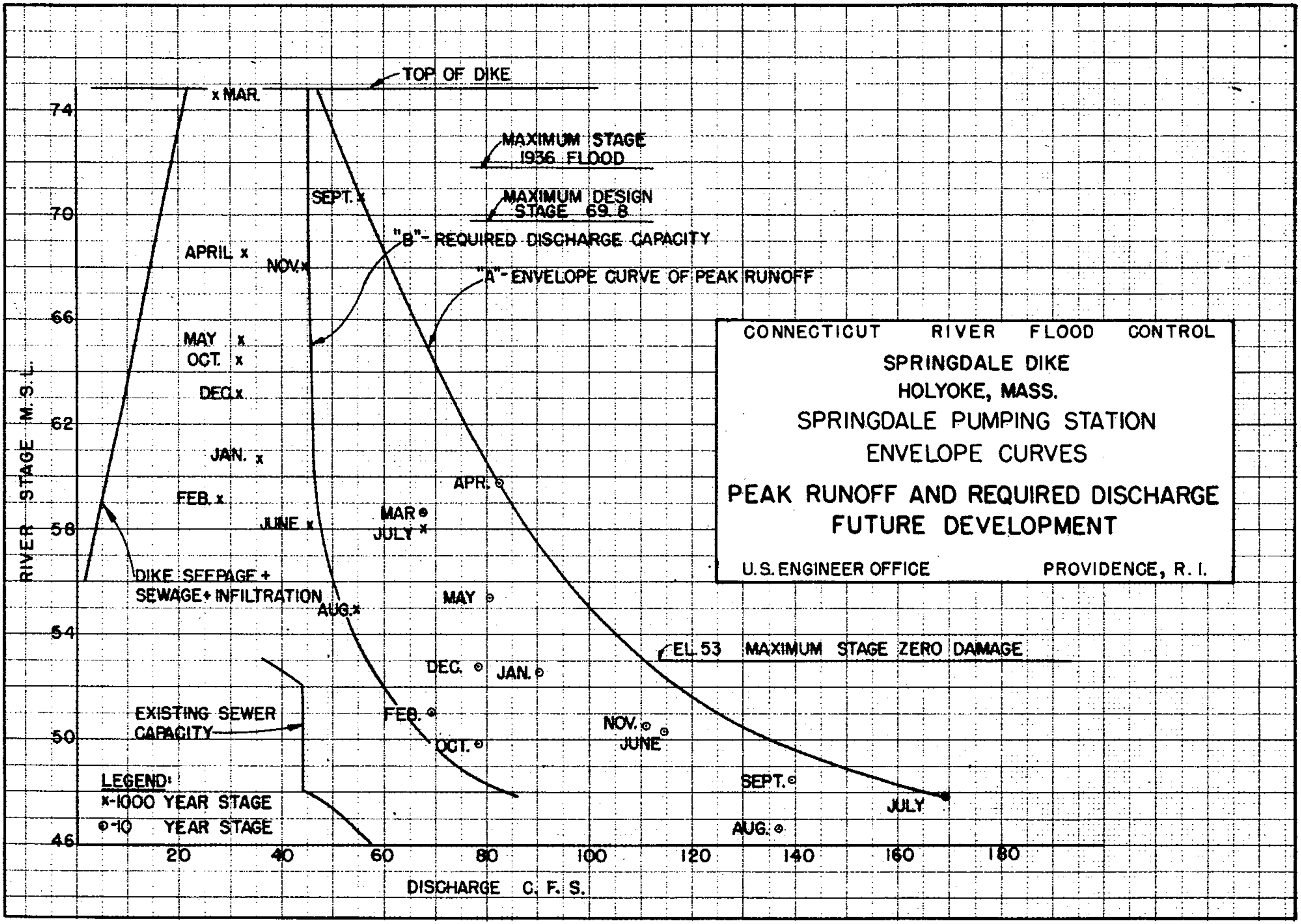
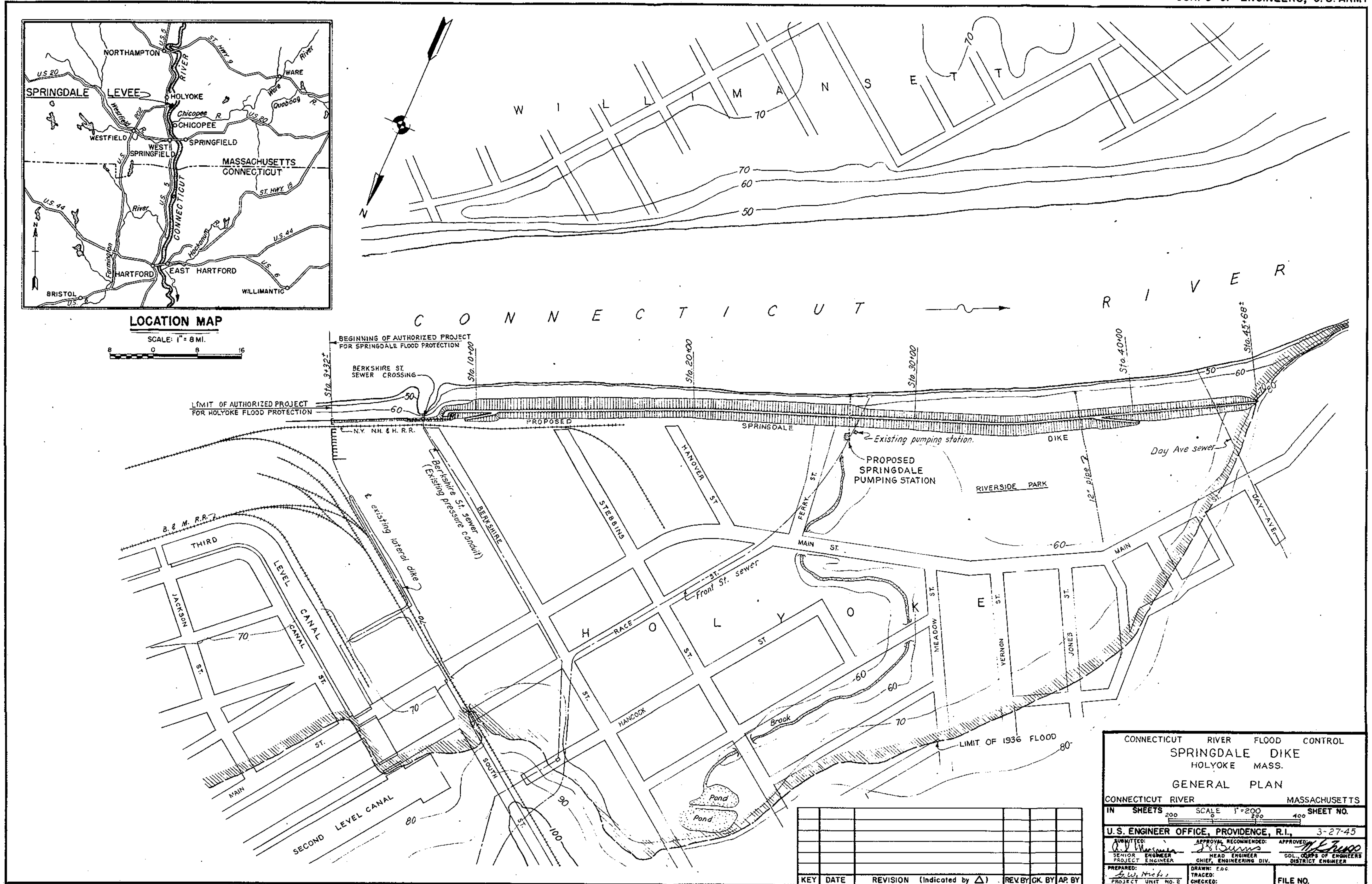


PLATE NO.7


LOCATION MAP
SCALE: 1" = 8 MI.
NORTHAMPTON
HOLYOKE
SPRINGDALE LEVEE
CHICOPEE
WESTFIELD
WEST SPRINGFIELD
SPRINGFIELD
MASSACHUSETTS
CONNECTICUT
HARTFORD
EAST HARTFORD
BRISTOL
WILLIMANTIC
WARE
CONNECTICUT RIVER
W I L L I M A N S E T T
H O L Y O K E
BEGINNING OF AUTHORIZED PROJECT FOR SPRINGDALE FLOOD PROTECTION
LIMIT OF AUTHORIZED PROJECT FOR HOLYOKE FLOOD PROTECTION
BERKSHIRE ST. SEWER CROSSING
Sta. 3+32±
Sta. 10+00
Sta. 20+00
Sta. 30+00
Sta. 40+00
Sta. 45+68±
PROPOSED SPRINGDALE DIKE
N.Y. NH. & H. R.R.
B. & M. R.R.
Existing pumping station
PROPOSED SPRINGDALE PUMPING STATION
RIVERSIDE PARK
Day Ave sewer
12" pipe
Berkshire St. sewer (Existing pressure conduit)
existing lateral dike
Front St. sewer
LIMIT OF 1936 FLOOD
Brook
Pond
THIRD LEVEL CANAL
SECOND LEVEL CANAL
CONNECTICUT RIVER FLOOD CONTROL
SPRINGDALE DIKE
HOLYOKE MASS.
GENERAL PLAN
CONNECTICUT RIVER MASSACHUSETTS
SCALE 1" = 200
U.S. ENGINEER OFFICE, PROVIDENCE, R.I. 3-27-45
SENIOR ENGINEER PROJECT ENGINEER
HEAD ENGINEER CHIEF, ENGINEERING DIV.
COL., CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: PROJECT UNIT NO. 2
DRAWN: TRACED: CHECKED:
FILE NO.
KEY DATE REVISION (Indicated by △) REV. BY CK. BY AP. BY

D.P.R. HI. 4

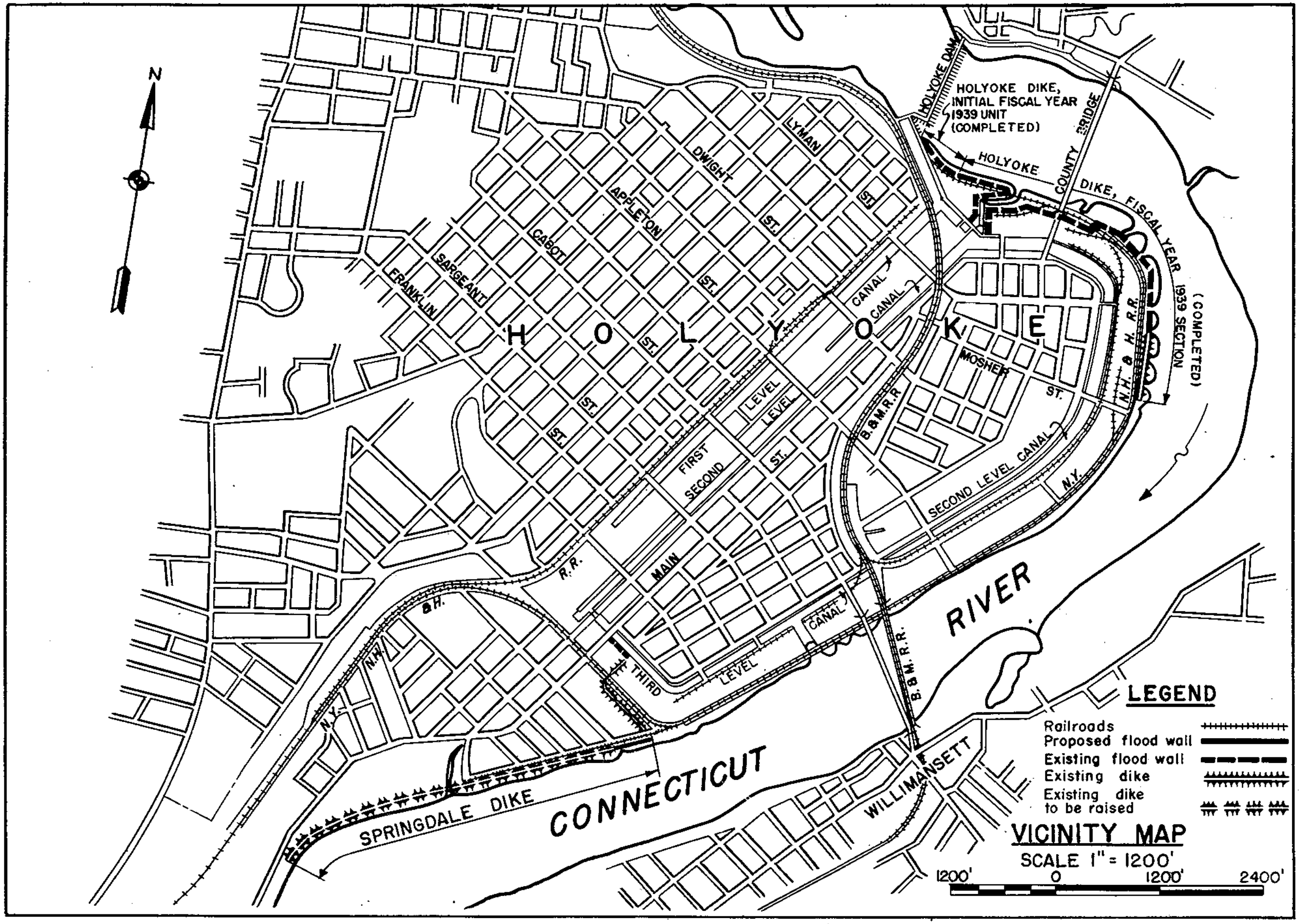
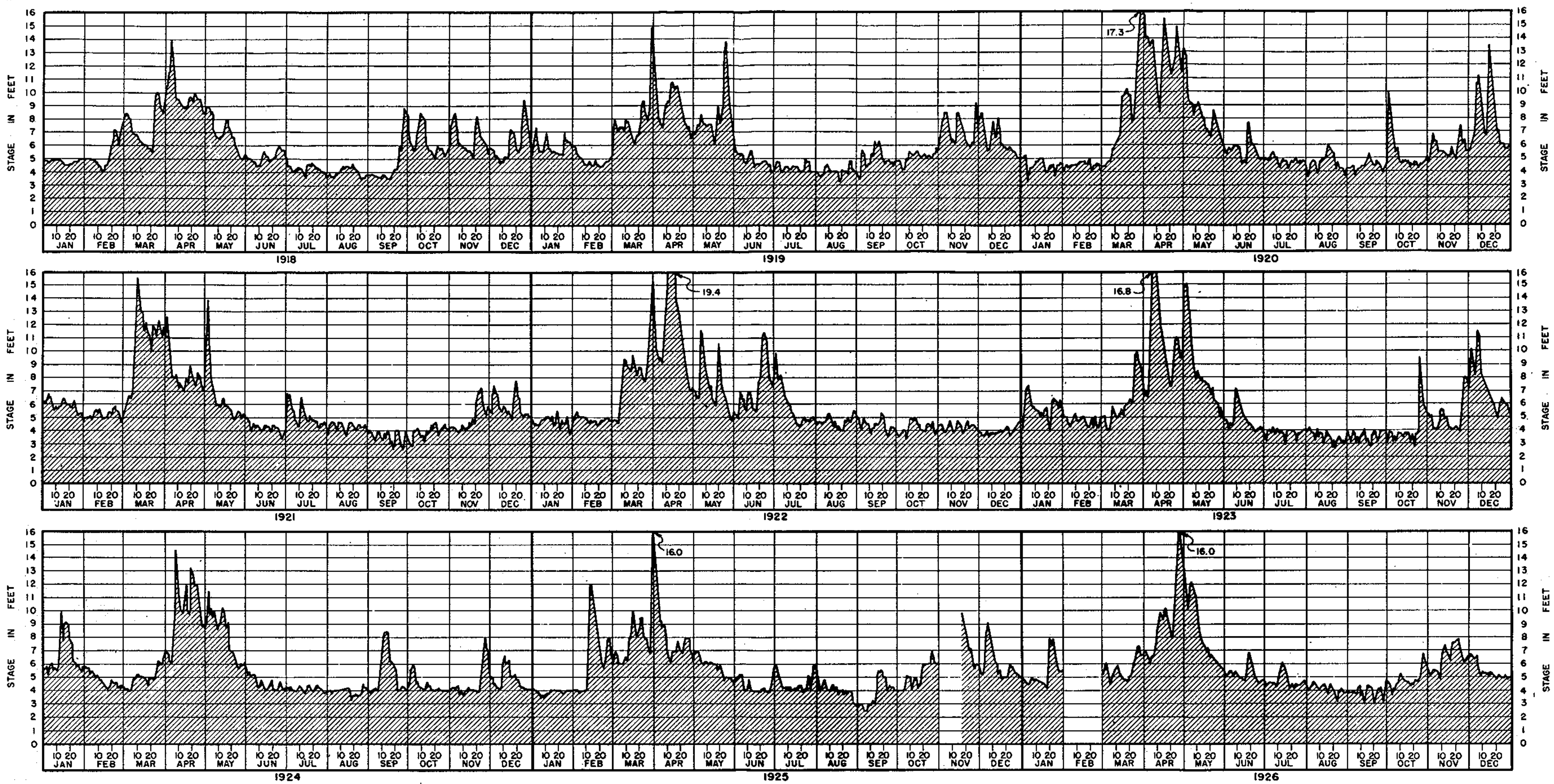
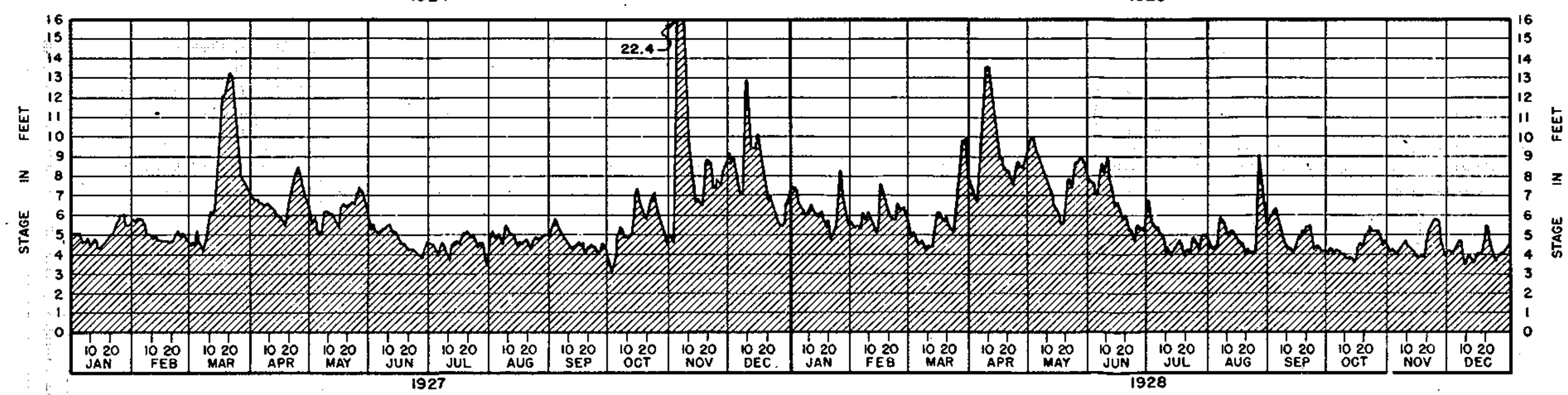


PLATE NO. 9

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY





NOTES

Stage records at Springfield obtained from United States Weather Bureau and from the Department of Streets and Engineering, City of Springfield.

Recording-gage located on upstream side of Memorial Bridge, Springfield, Mass.

Zero of gage is at elevation 37.3 m.s.l.

For stage relation curve see Sheet No. 4.

KEY	DATE	REVISION (Indicated by Δ)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

HOLYOKE, MASS.

HYDROGRAPH NO.1, CONNECTICUT RIVER

CONNECTICUT RIVER — MASSACHUSETTS

IN SHEETS — SHEET NO.

SCALE AS SHOWN

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

SUBMITTED: [signature] SENIOR ENGINEER HEAD, HYDRAULICS SECTION

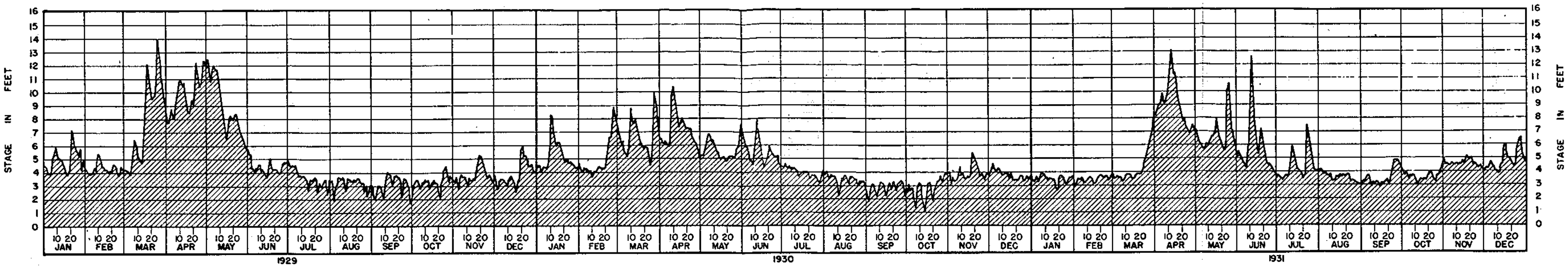
APPROVAL RECOMMENDED: [signature] HEAD ENGINEER CHIEF, ENGINEERING DIV.

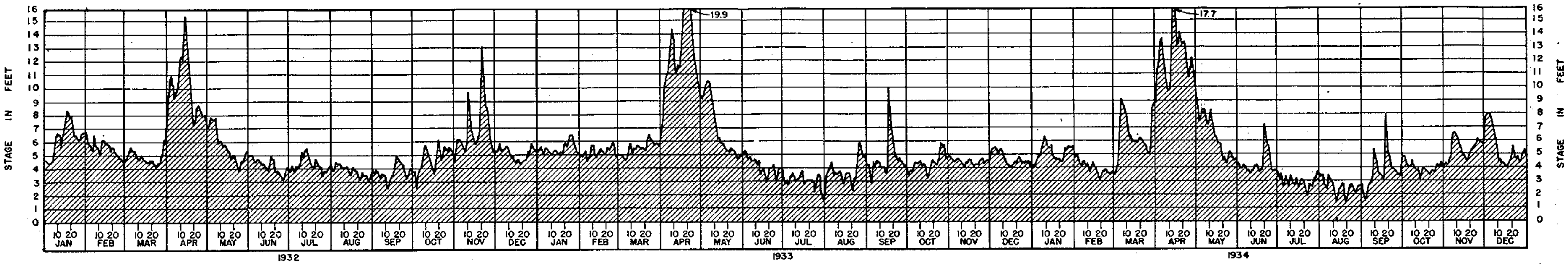
APPROVED: [signature] COL. CORPS OF ENGINEERS DISTRICT ENGINEER

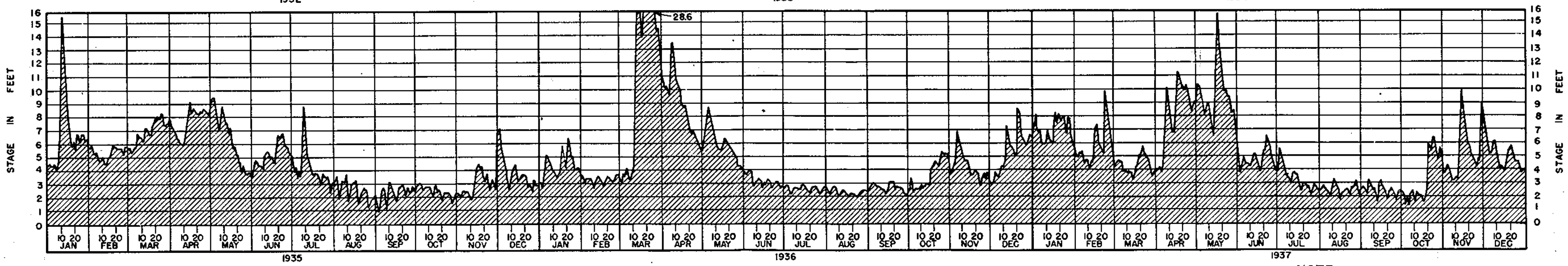
PREPARED: Robert Forbes HYDRAULICS SECTION

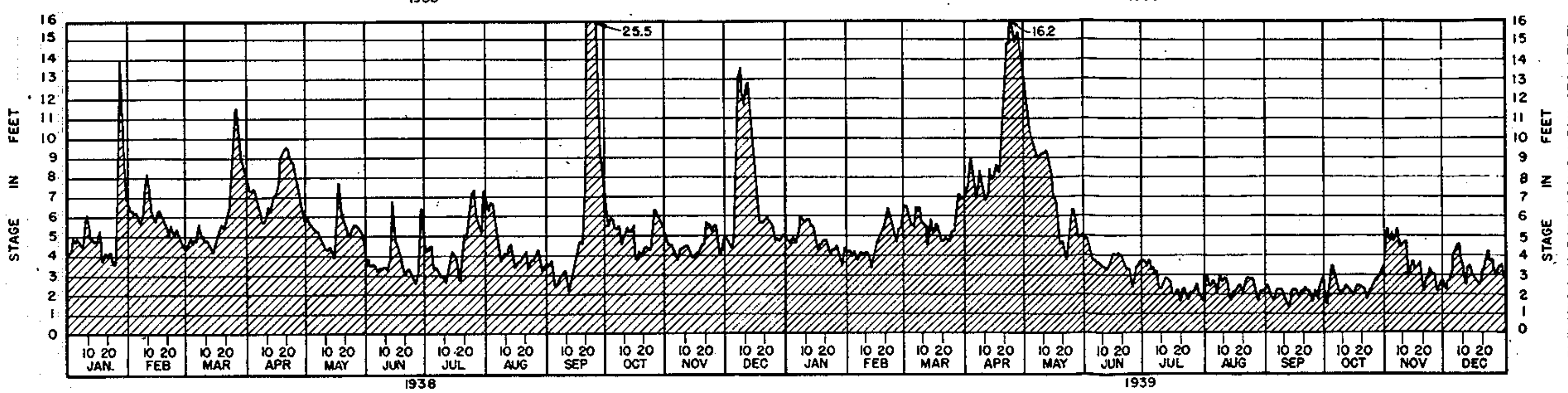
DRAWN: W.C.N. & G.A.L.
TRACED: L.V.P.
CHECKED: W.C.N.

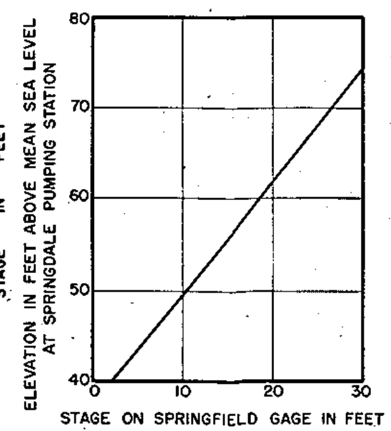
FILE NO. CT-3-1248











STAGE RELATION CURVE

NOTE

For general notes applying to this sheet, see Sheet No. 3.

KEY	DATE	REVISION (indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

HOLYOKE, MASS.

HYDROGRAPH NO. 2, CONNECTICUT RIVER

CONNECTICUT RIVER MASSACHUSETTS

IN SHEET NO.

SCALE AS SHOWN

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

SUBMITTED: [signature] SENIOR ENGINEER HEAD, HYDRAULICS SECTION

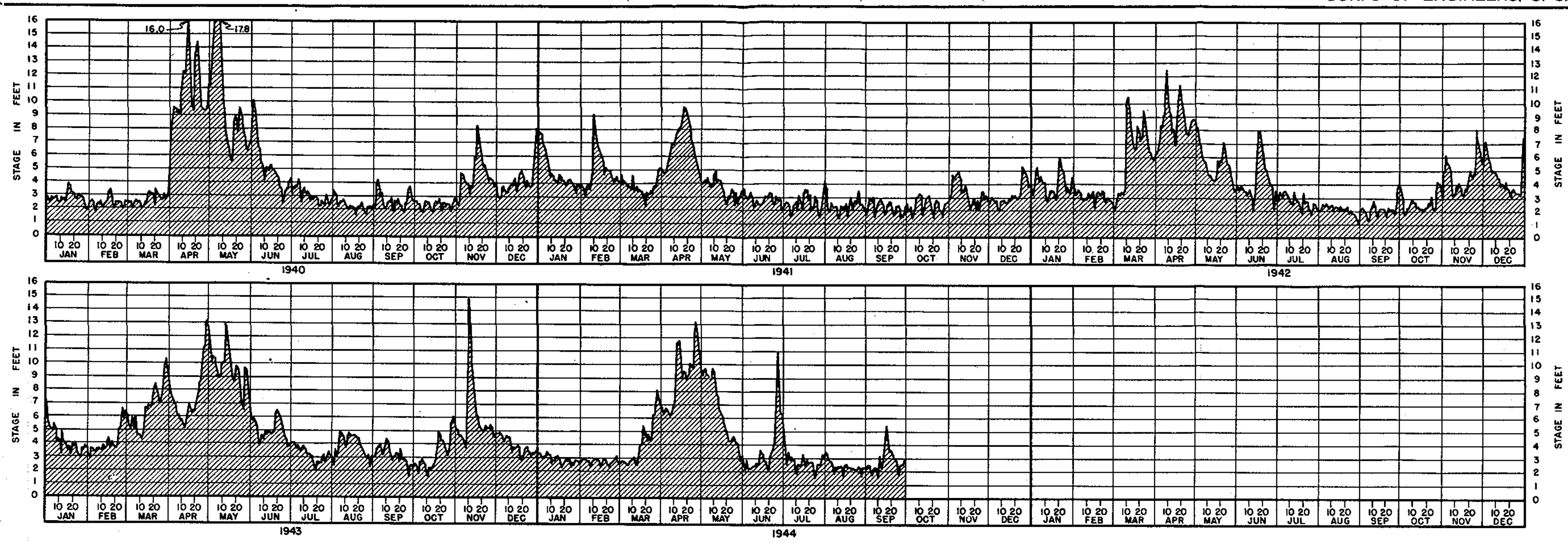
APPROVAL RECOMMENDED: [signature] HEAD ENGINEER CHIEF, ENGINEERING DIV.

APPROVED: [signature] COL. CORPS OF ENGINEERS DISTRICT ENGINEER

PREPARED: Robert Forbes HYDRAULICS SECTION

DRAWN: W.C.L. & G.A.L.
TRACED: A.J.H.
CHECKED:

FILE NO. CT-3-1249



NOTES

For general notes applying to this sheet see Sheet No. 2.

KEY	DATE	REVISION (Indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

HOLYOKE, MASS.

HYDROGRAPH NO. 3, CONNECTICUT RIVER

CONNECTICUT RIVER MASSACHUSETTS

IN SHEETS SHEET NO.

SCALE AS SHOWN

U. S. ENGINEER OFFICE, PROVIDENCE, R.I.,

SUBMITTED: [signature] SENIOR ENGINEER HEAD, HYDRAULICS SECTION

APPROVAL RECOMMENDED: [signature] HEAD ENGINEER CHIEF, ENGINEERING DIV.

APPROVED: [signature] COL., CORPS OF ENGINEERS DISTRICT ENGINEER

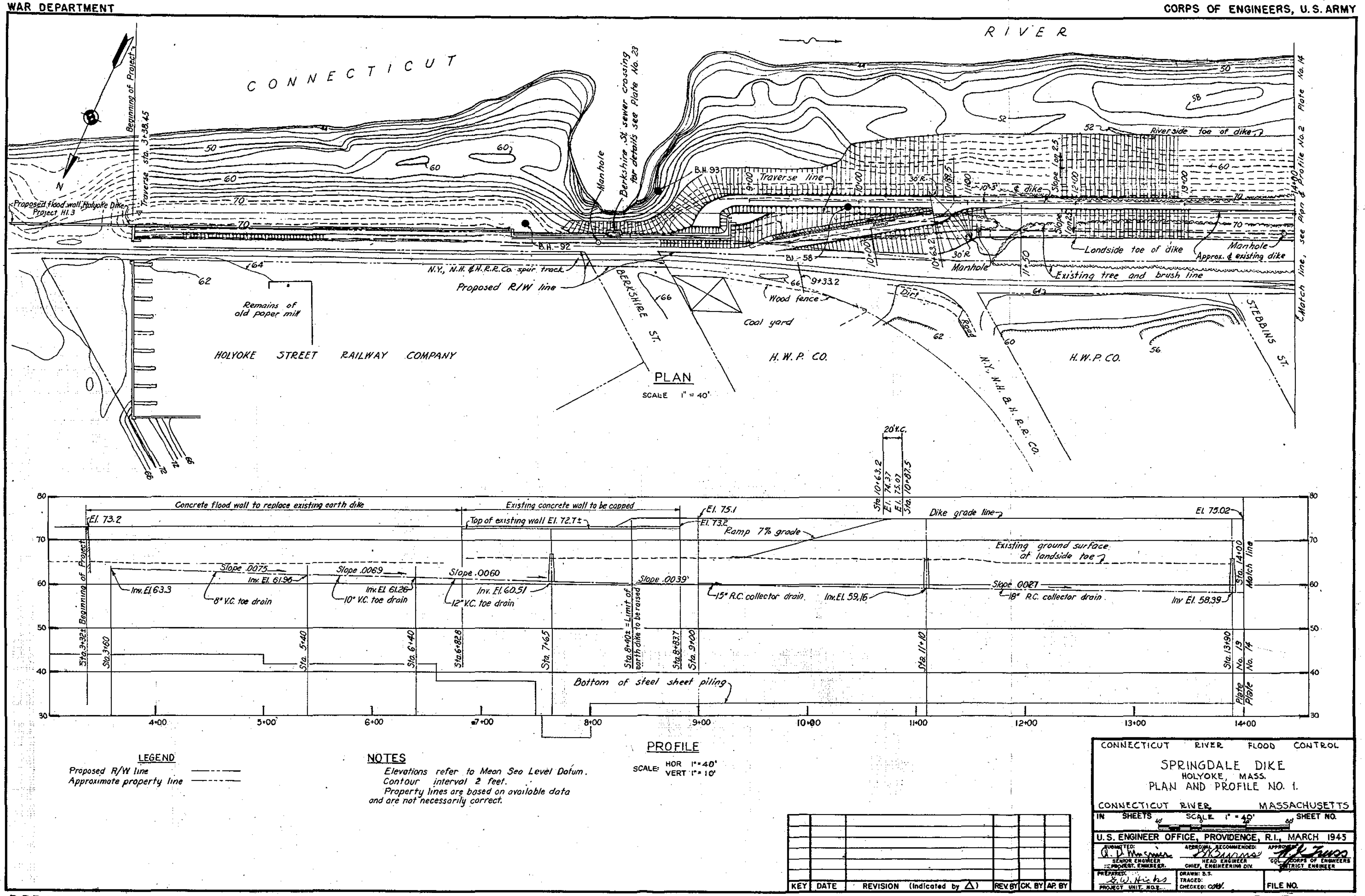
PREPARED: Robert Forbes HYDRAULICS SECTION

DRAWN: D.W.C.
TRACED: V.S.C.
CHECKED: [signature]

FILE NO. CT-3-1250

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

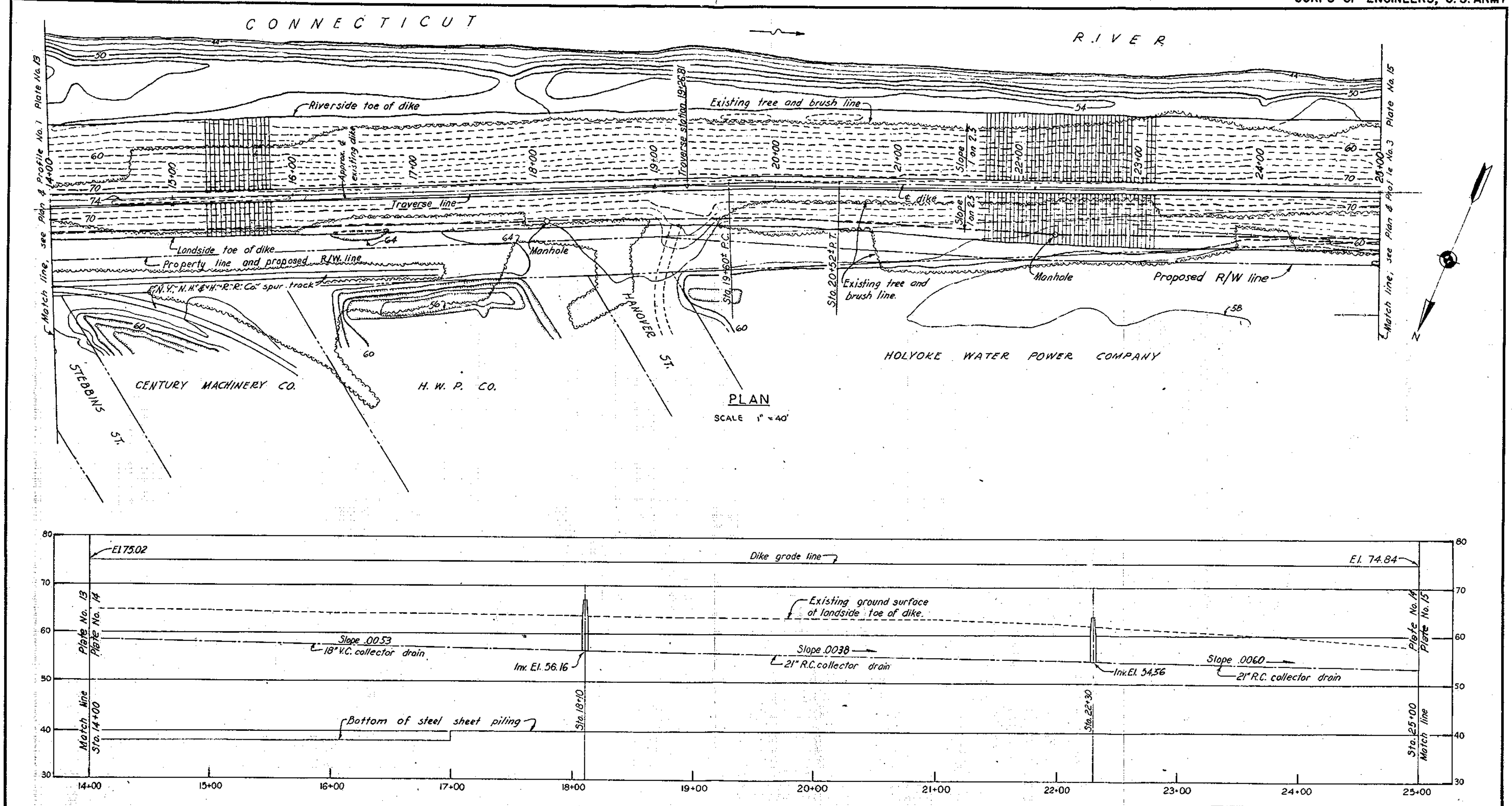


D.P.R. HI. 4

PLATE NO. 13

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



NOTES
For general notes and legend, see Plate No. 13

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
HOLYOKE, MASS.
PLAN AND PROFILE NO. 2.

CONNECTICUT RIVER — MASSACHUSETTS

IN SHEETS — SCALE 1" = 40' — SHEET NO.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

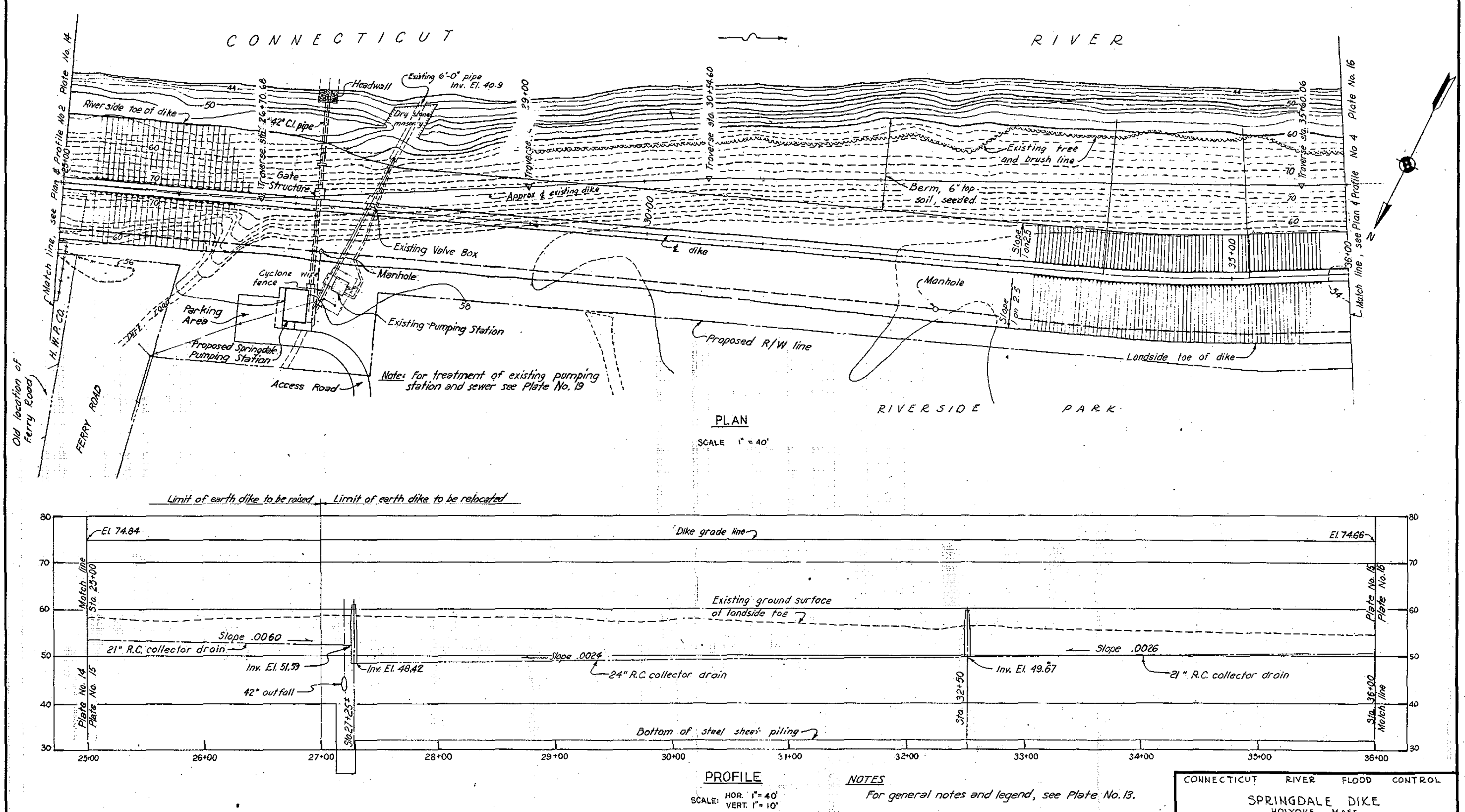
SUBMITTED: G. D. Wuerner, SENIOR ENGINEER, PROJECT ENGINEER — APPROVAL RECOMMENDED: W. Burns, HEAD ENGINEER, CHIEF, ENGINEERING DIV. — APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: S. W. Nelson — DRAWN: B.S. — TRACED: — CHECKED: C.W. — FILE NO.

PROJECT UNIT NO. 2

D.P.R.HI. 4

PLATE NO.14



NOTES

For general notes and legend, see Plate No. 13.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
HOLYOKE, MASS.
PLAN AND PROFILE NO. 3.

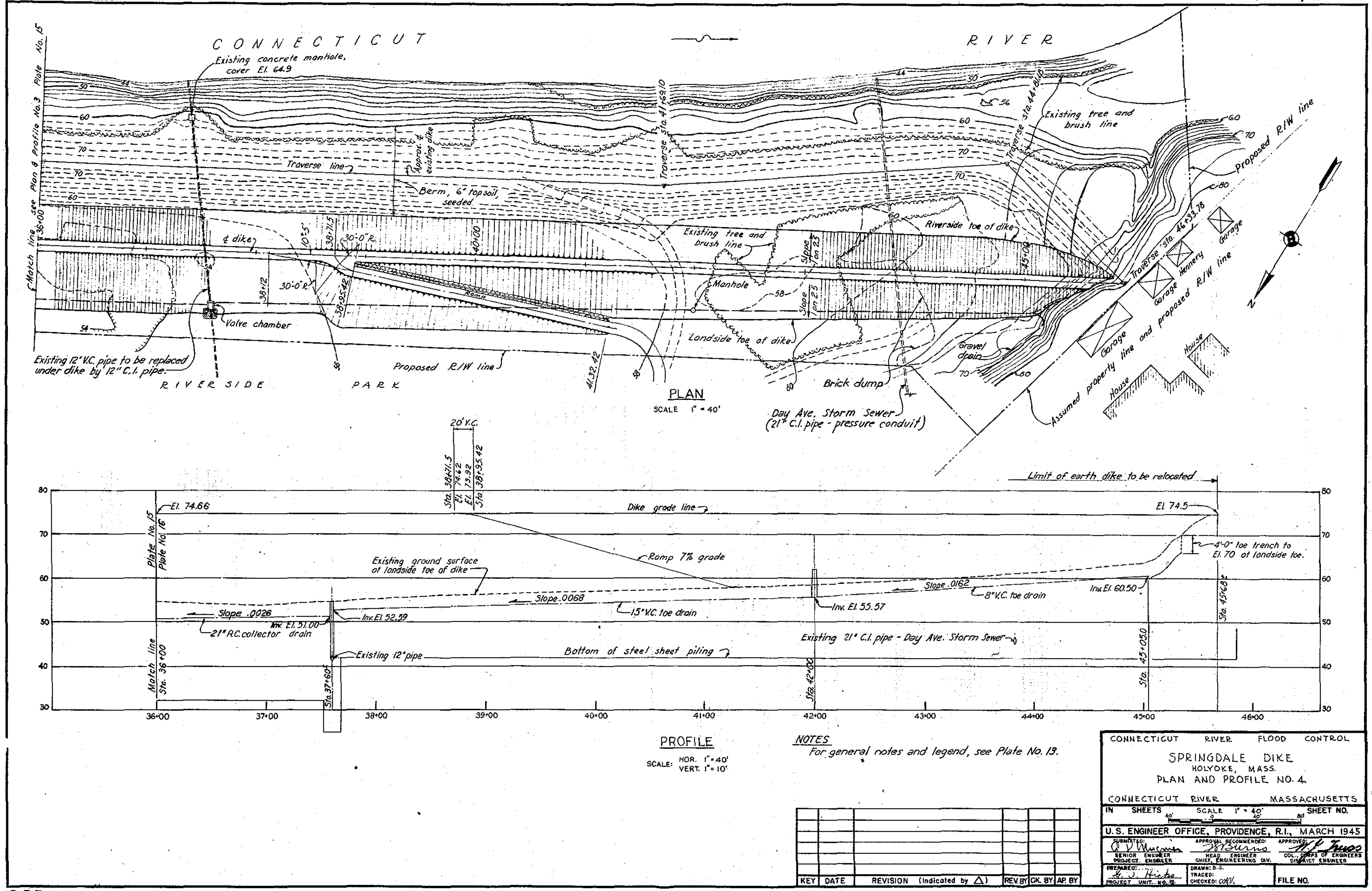
CONNECTICUT RIVER — MASSACHUSETTS

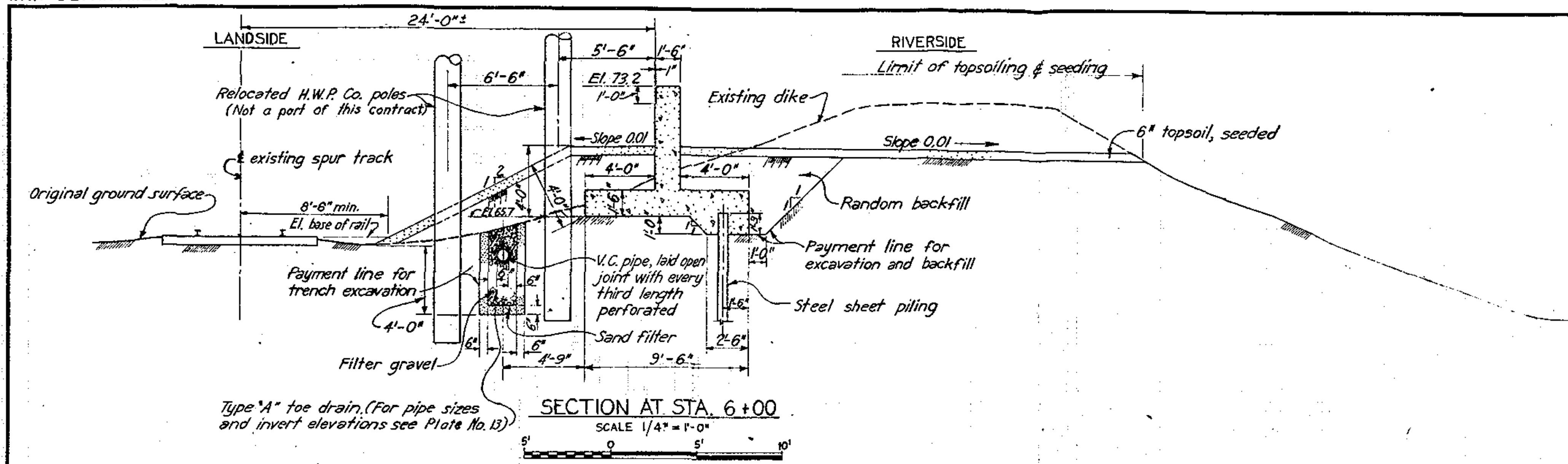
IN SHEETS — SCALE 1" = 40' — SHEET NO.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

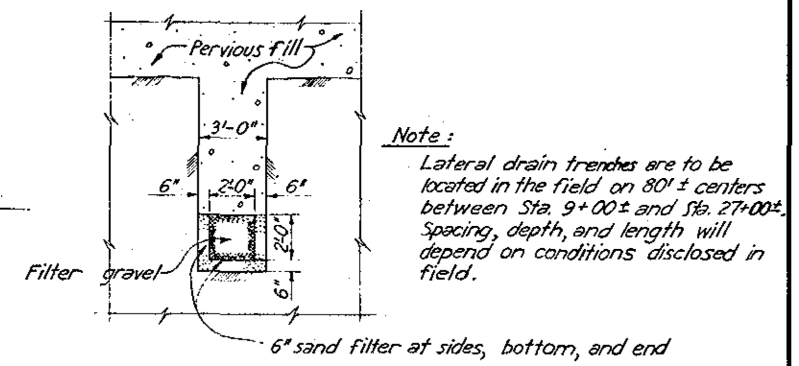
SUBMITTED: SENIOR ENGINEER PROJECT ENGINEER — APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS DISTRICT ENGINEER

PREPARED: PROJECT UNIT NO. 2 — DRAWN: B.S. TRACED: CHECKED: — FILE NO.


CONNECTICUT RIVER
Existing concrete manhole, cover El. 64.9
Match line Sta. 36+00 see Plan & Profile No. 3 Plate No. 15
Traverse line
Approx. ℄ existing dike
Berm, 6" top soil, seeded
Traverse Sta. 41+69.10
Traverse Sta. 44+81.0
Existing tree and brush line
Proposed R/W line
℄ dike
Riverside toe of dike
Traverse Sta. 46+33.78
Garage
Hennery
Slope 1 on 2.5
Manhole
Ramp
Valve chamber
Landside toe of dike
Gravel drain
Existing 12" V.C. pipe to be replaced under dike by 12" C.I. pipe.
Proposed R/W line
Brick dump
Assumed property line and proposed R/W line
House
RIVER SIDE PARK
PLAN
SCALE 1" = 40'
Day Ave. Storm Sewer (21" C.I. pipe - pressure conduit)
20' V.C.
Sta. 38+71.5 El. 74.42 El. 73.92 Sta. 38+95.42
Limit of earth dike to be relocated
El. 74.66
Dike grade line
El. 74.5
Plate No. 15 Plate No. 16
4'-0" toe trench to El. 70 at landside toe.
Existing ground surface at landside toe of dike
Ramp 7% grade
Slope .0162
Inv. El. 60.50
8" V.C. toe drain
Slope .0068
Slope .0026
15" V.C. toe drain
Inv. El. 55.57
Inv. El. 51.00
Inv. El. 52.59
21" R.C. collector drain
Existing 21" C.I. pipe - Day Ave. Storm Sewer
Existing 12" pipe
Bottom of steel sheet piling
Match line Sta. 36+00
Sta. 37+60±
Sta. 42+00
Sta. 45+05.0
Sta. 45+68±
36+00 37+00 38+00 39+00 40+00 41+00 42+00 43+00 44+00 45+00 46+00
PROFILE
SCALE: HOR. 1" = 40' VERT. 1" = 10'
NOTES
For general notes and legend, see Plate No. 13.
KEY DATE REVISION (Indicated by △) REV. BY CK. BY AP. BY
CONNECTICUT RIVER FLOOD CONTROL
SPRINGDALE DIKE
HOLYOKE, MASS.
PLAN AND PROFILE NO. 4
CONNECTICUT RIVER MASSACHUSETTS
IN SHEETS SCALE 1" = 40' SHEET NO.
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945
SUBMITTED: SENIOR ENGINEER PROJECT ENGINEER
APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV.
APPROVED: COL., CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: PROJECT UNIT
DRAWN: B.S.
TRACED:
CHECKED:
FILE NO.

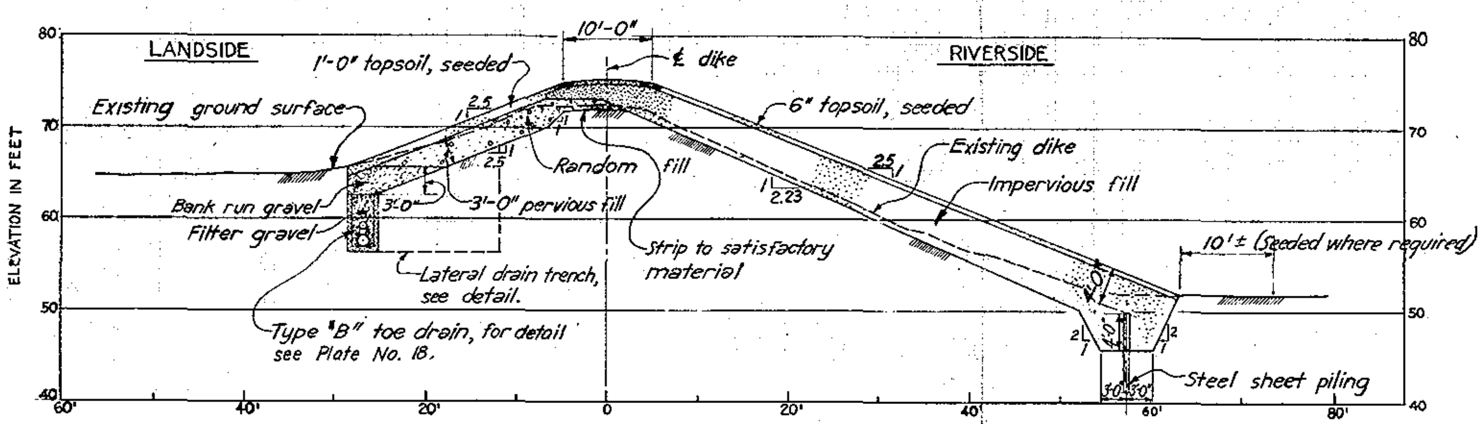


SECTION AT STA. 6+00
SCALE 1/4" = 1'-0"

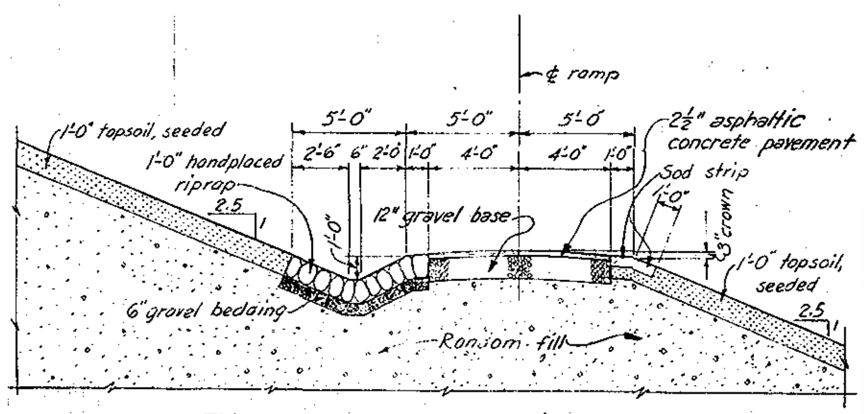


Note: Lateral drain trenches are to be located in the field on 80' ± centers between Sta. 9+00± and Sta. 27+00±. Spacing, depth, and length will depend on conditions disclosed in field.

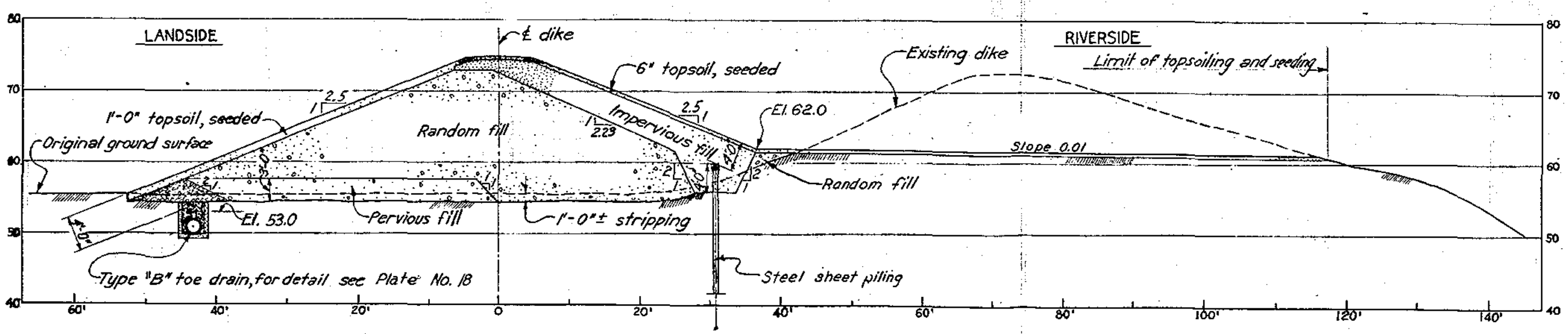
LATERAL DRAIN TRENCH
SCALE 1/4" = 1'-0"



SECTION AT STA. 17+00
SCALE 1" = 10'-0"



TYPICAL SECTION THRU RAMP
SCALE 1/4" = 1'-0"



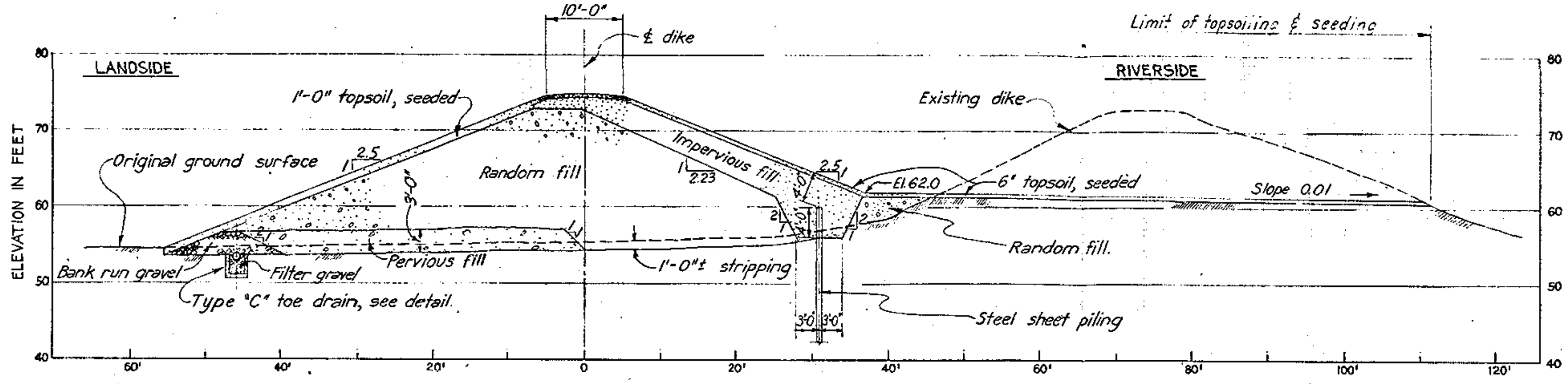
SECTION AT STA. 33+00
SCALE 1" = 10'-0"

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

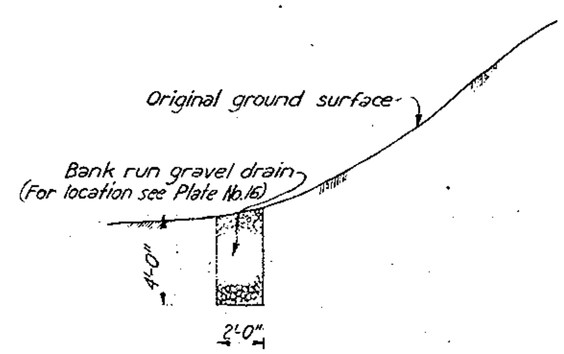
CONNECTICUT RIVER FLOOD CONTROL
SPRINGDALE DIKE
HOLYOKE, MASS.
EMBANKMENT DETAILS NO. 1

CONNECTICUT RIVER — MASSACHUSETTS
IN SHEETS — SCALE AS SHOWN — SHEET NO.
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

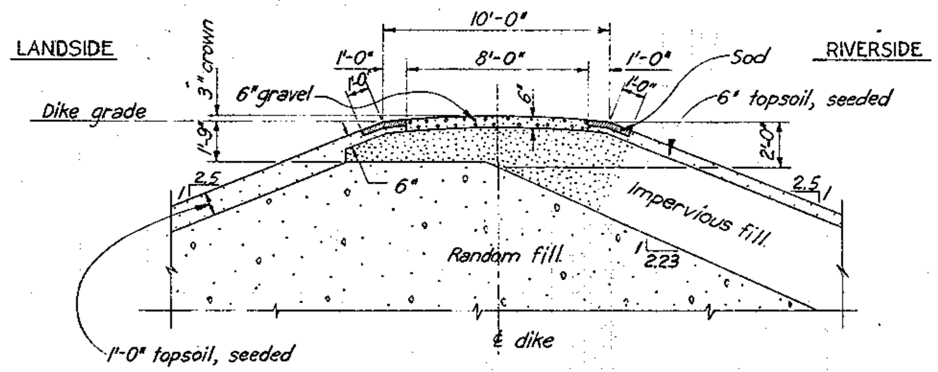
SUBMITTED: SENIOR ENGINEER, PROJECT ENGINEER — APPROVAL RECOMMENDED: HEAD ENGINEER, CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: PROJECT UNIT NO. 2 — DRAWN: C.W.V. TRACED: CHECKED: — FILE NO.



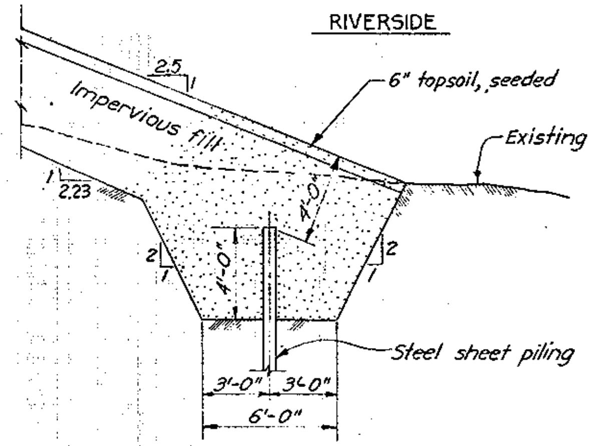
SECTION AT STA. 38+00
SCALE 1" = 10'-0"



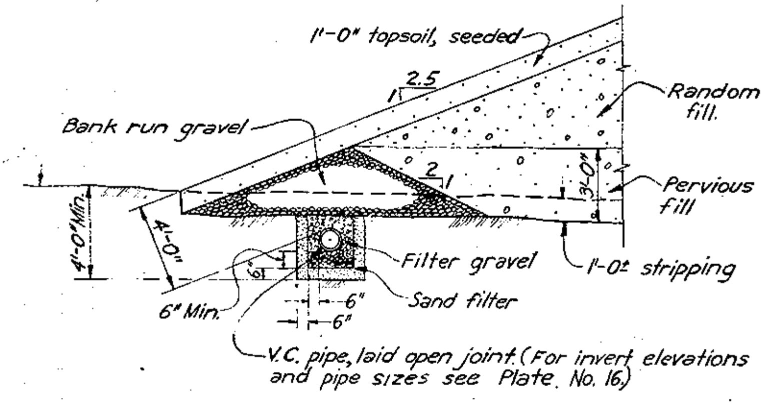
DETAIL OF GRAVEL DRAIN
SCALE 1/4" = 1'-0"



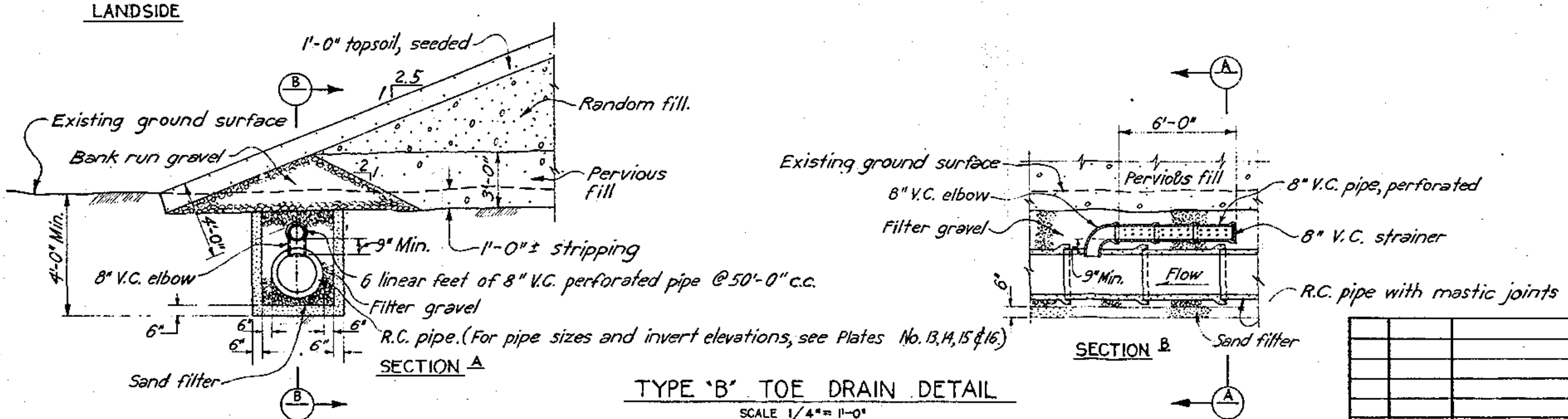
DETAIL OF TOP OF DIKE
SCALE 1/4" = 1'-0"



DETAIL OF CUT-OFF TRENCH
SCALE 1/4" = 1'-0"



TYPE 'C' TOE DRAIN DETAIL
TYPICAL FROM STA. 37+60± TO STA. 45+05±
SCALE 1/4" = 1'-0"

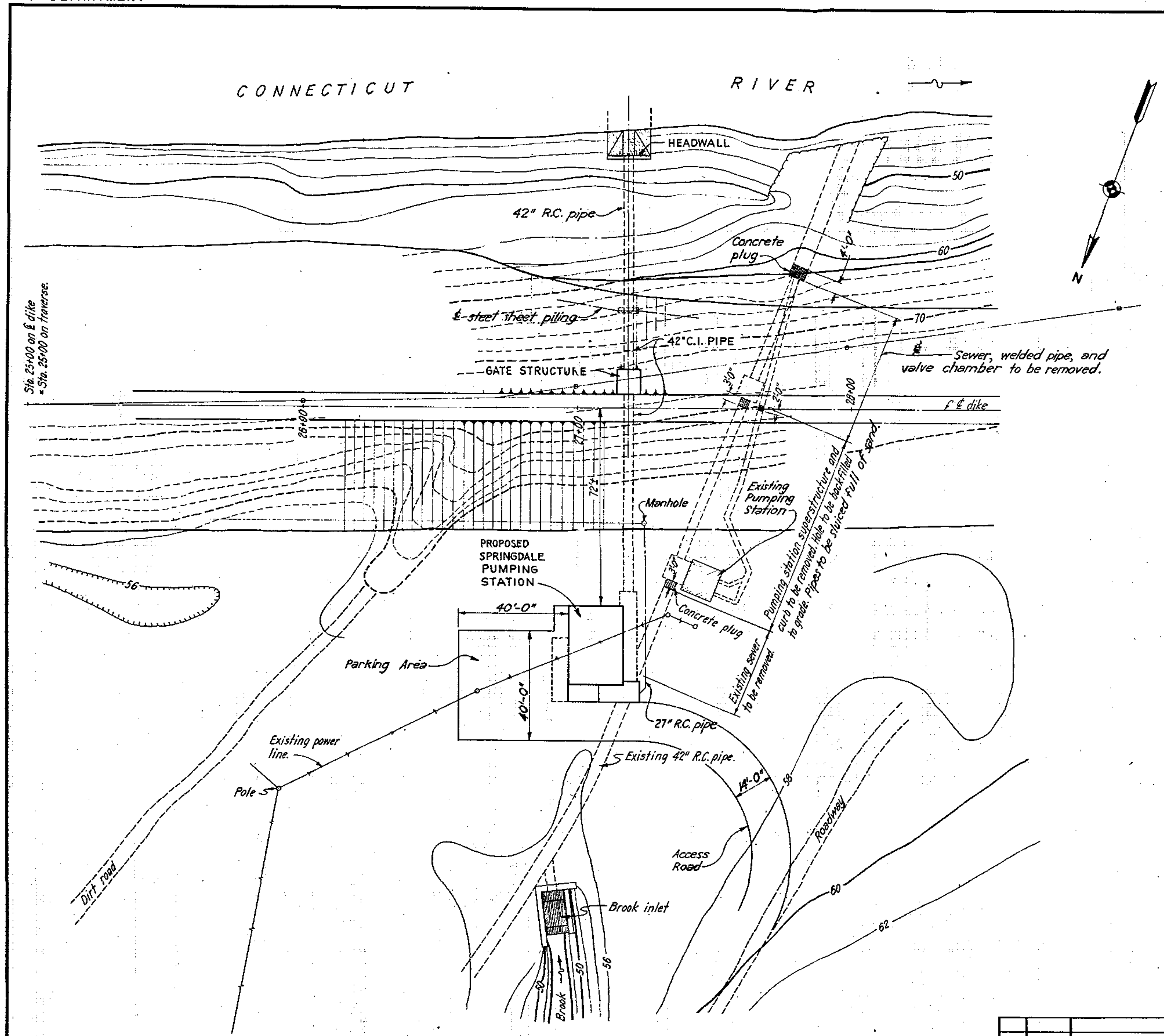


TYPE 'B' TOE DRAIN DETAIL
SCALE 1/4" = 1'-0"

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL
SPRINGDALE DIKE
HOLYOKE, MASS.
EMBANKMENT DETAILS NO. 2

CONNECTICUT RIVER — MASSACHUSETTS
IN SHEETS — SHEET NO.
SCALE AS SHOWN
U. S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945
SUBMITTED: SENIOR ENGINEER, PROJECT ENGINEER
APPROVAL RECOMMENDED: HEAD ENGINEER, CHIEF, ENGINEERING DIV.
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: PROJECT UNIT NO. 2
DRAWN: C.W.V.
TRACED:
CHECKED:
FILE NO.



PLAN

SCALE: 1" = 20'

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

HOLYOKE, MASS.

SPRINGDALE PUMPING STATION

GENERAL PLAN

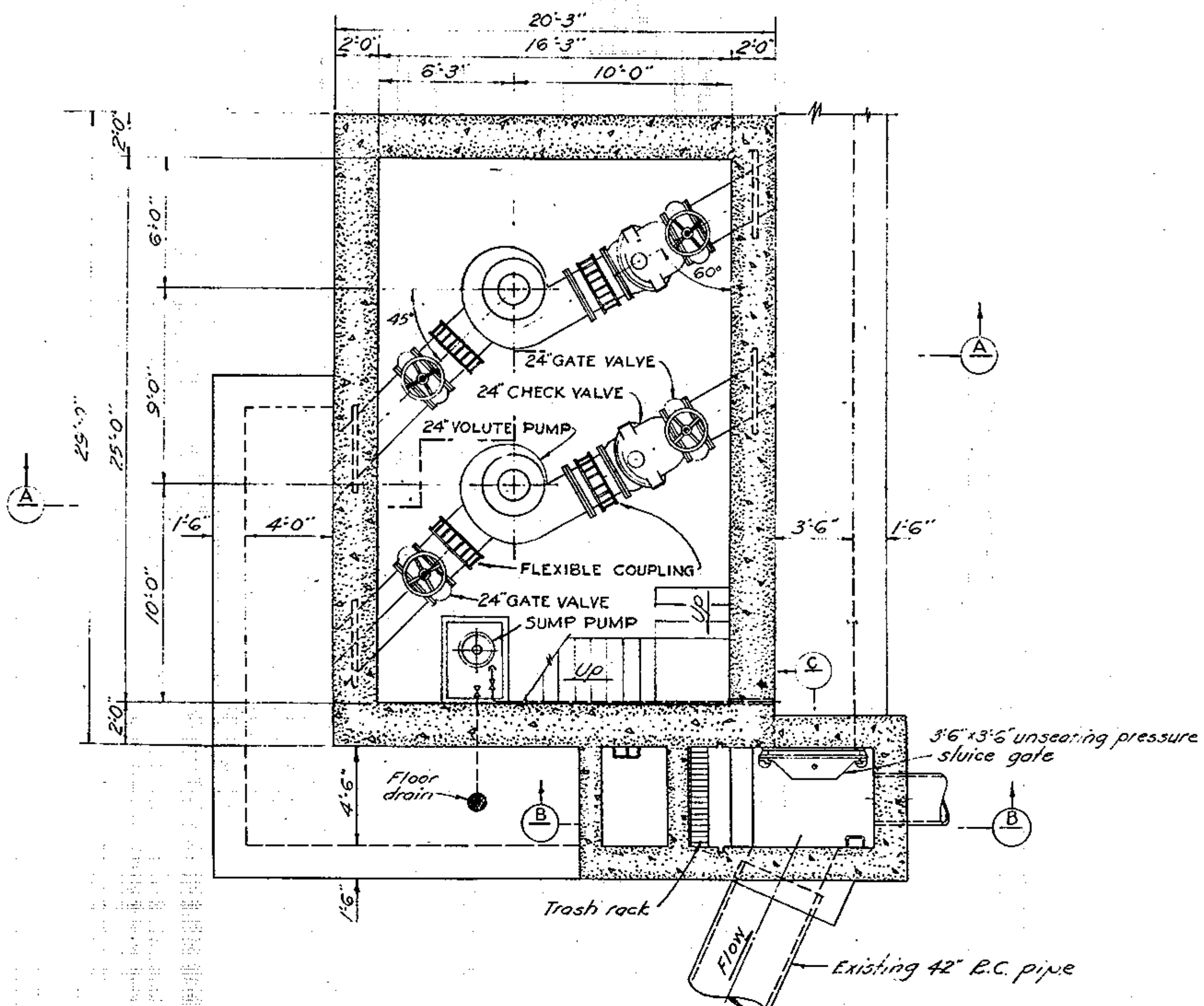
CONNECTICUT RIVER — MASSACHUSETTS

IN SHEETS — SCALE 1 IN. = 20 FT. — SHEET NO.

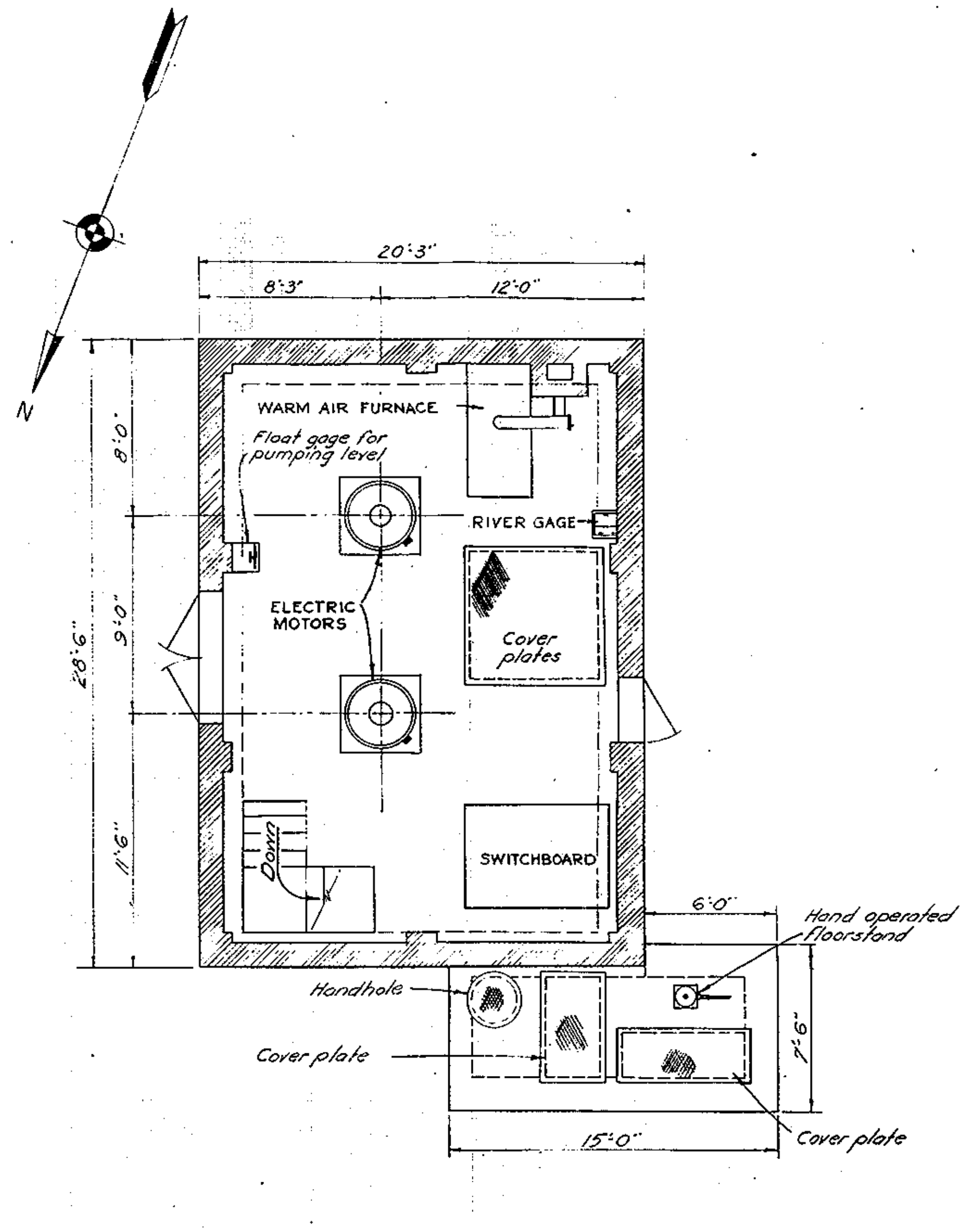
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

SUBMITTED: SENIOR ENGINEER, PROJECT ENGINEER — APPROVAL RECOMMENDED: HEAD ENGINEER, CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: E. W. Hicks, PROJECT UNIT NO. 2 — DRAWN: T.C.M. — TRACED: — CHECKED: — FILE NO.



PUMP ROOM PLAN



ENGINE ROOM PLAN

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE PUMPING STATION

HOLYOKE MASS.

GENERAL ARRANGEMENT OF EQUIPMENT NO. I

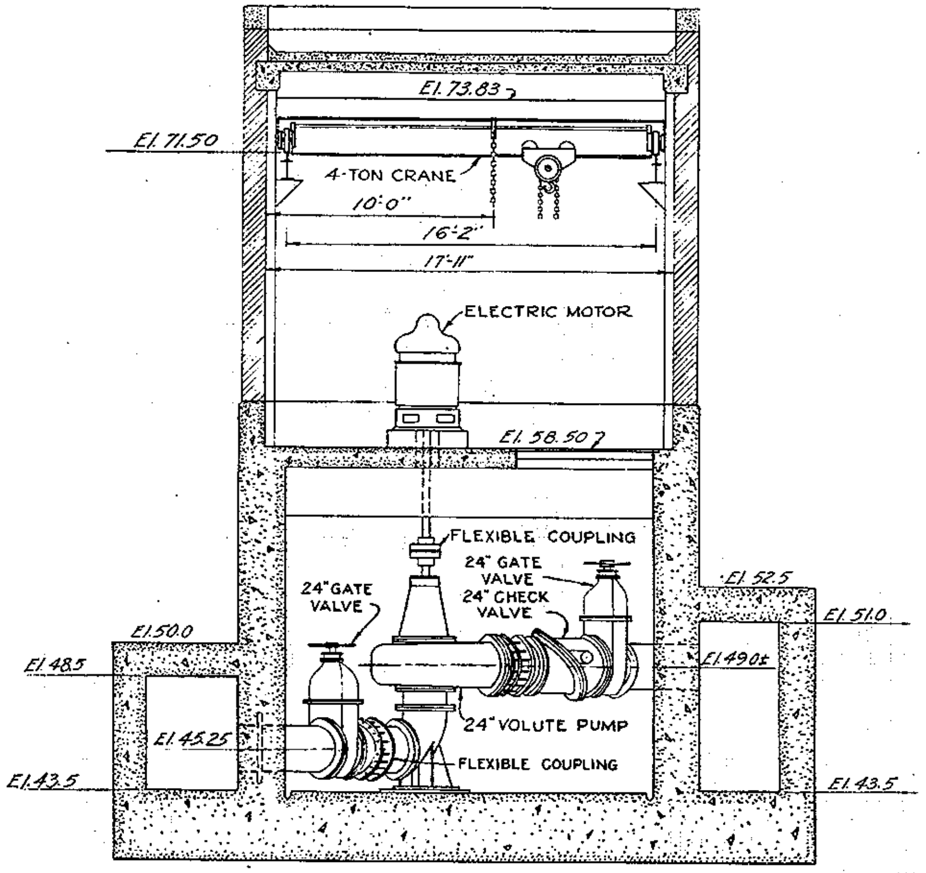
CONNECTICUT RIVER MASSACHUSETTS

IN SHEETS SCALE: 1/4 IN. = 1 FT. SHEET NO.

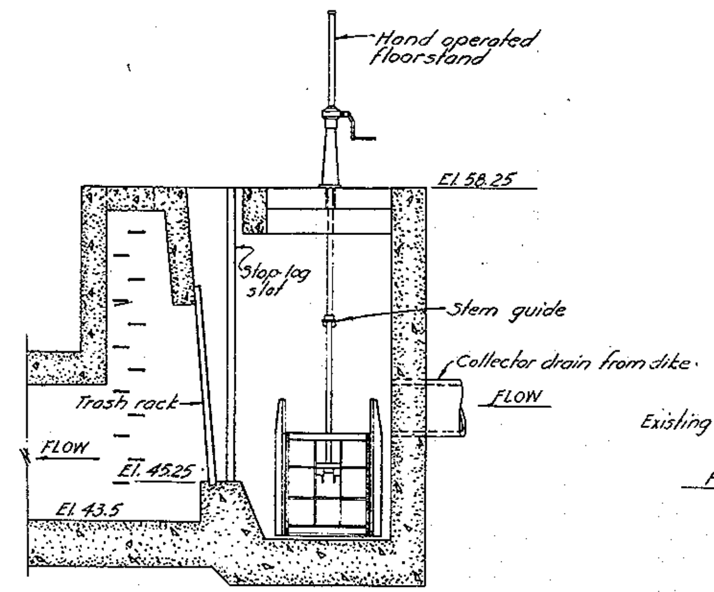
U. S. ENGINEER OFFICE, PROVIDENCE, R.I.

SUBMITTED: H. J. Knobber, SENIOR ENGINEER, HEAD MECHANICAL SECTION
APPROVAL RECOMMENDED: [signature], HEAD ENGINEER, CHIEF, ENGINEERING DIV.
APPROVED: [signature], COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

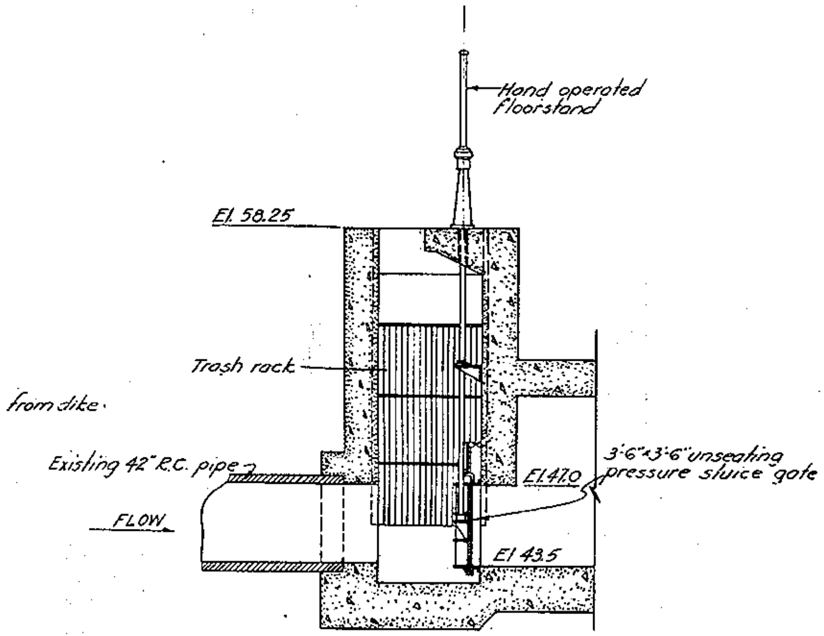
PREPARED: [signature], MECHANICAL SUBSECTION
DRAWN: F. J. G.
TRACED:
CHECKED:
FILE NO.



SECTION A



SECTION B



SECTION C

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE PUMPING STATION

HOLYOKE, MASS.

GENERAL ARRANGEMENT OF EQUIPMENT NO. 2

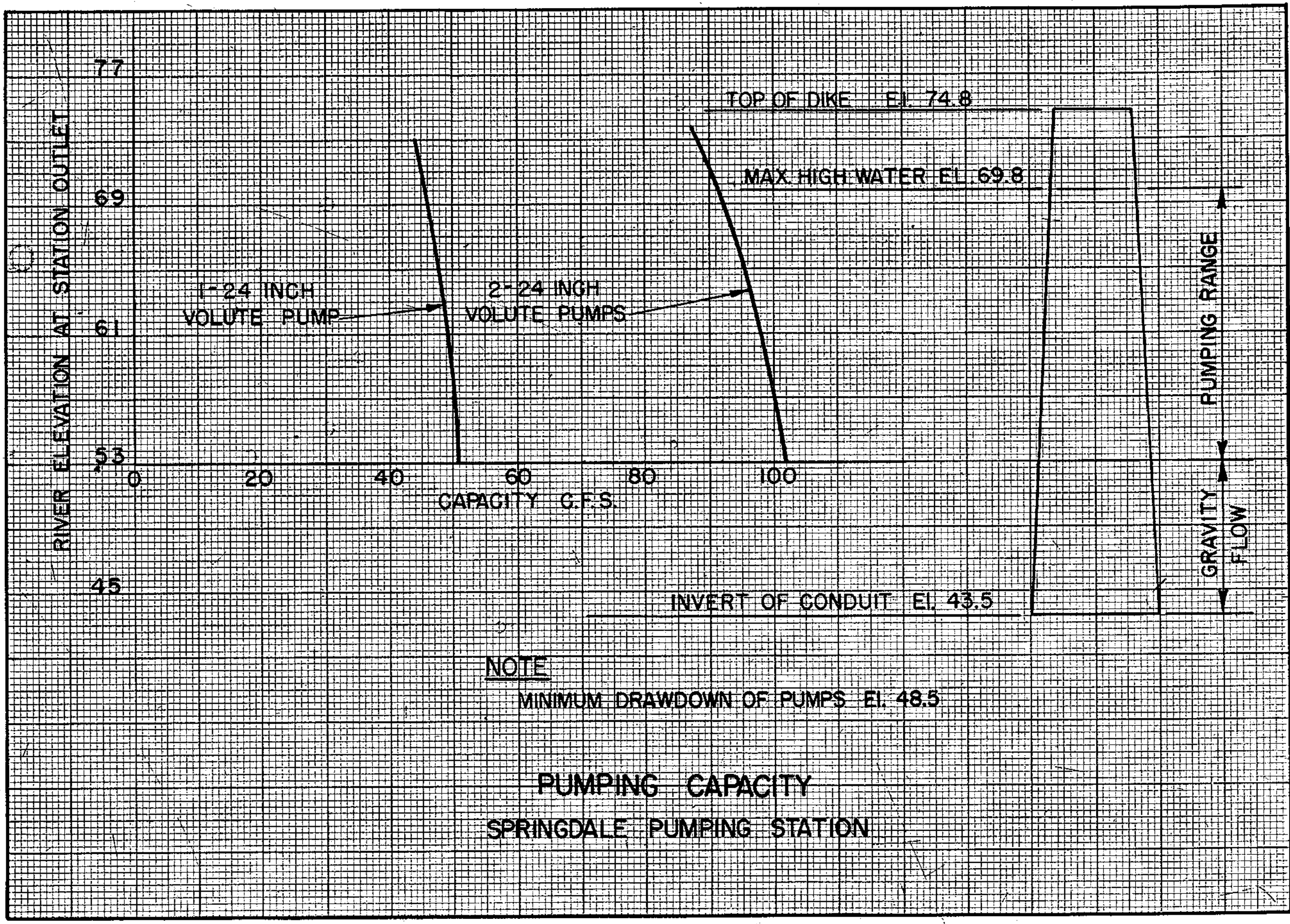
CONNECTICUT RIVER — MASSACHUSETTS

IN SHEETS — SCALE 1/4 IN. = 1 FT. — SHEET NO.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

SUBMITTED: SENIOR ENGINEER, HEAD MECHANICAL SECTION — APPROVAL RECOMMENDED: HEAD ENGINEER, CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: MECHANICAL SUBSECTION — DRAWN: F.J.G. — TRACED: — CHECKED: — FILE NO.

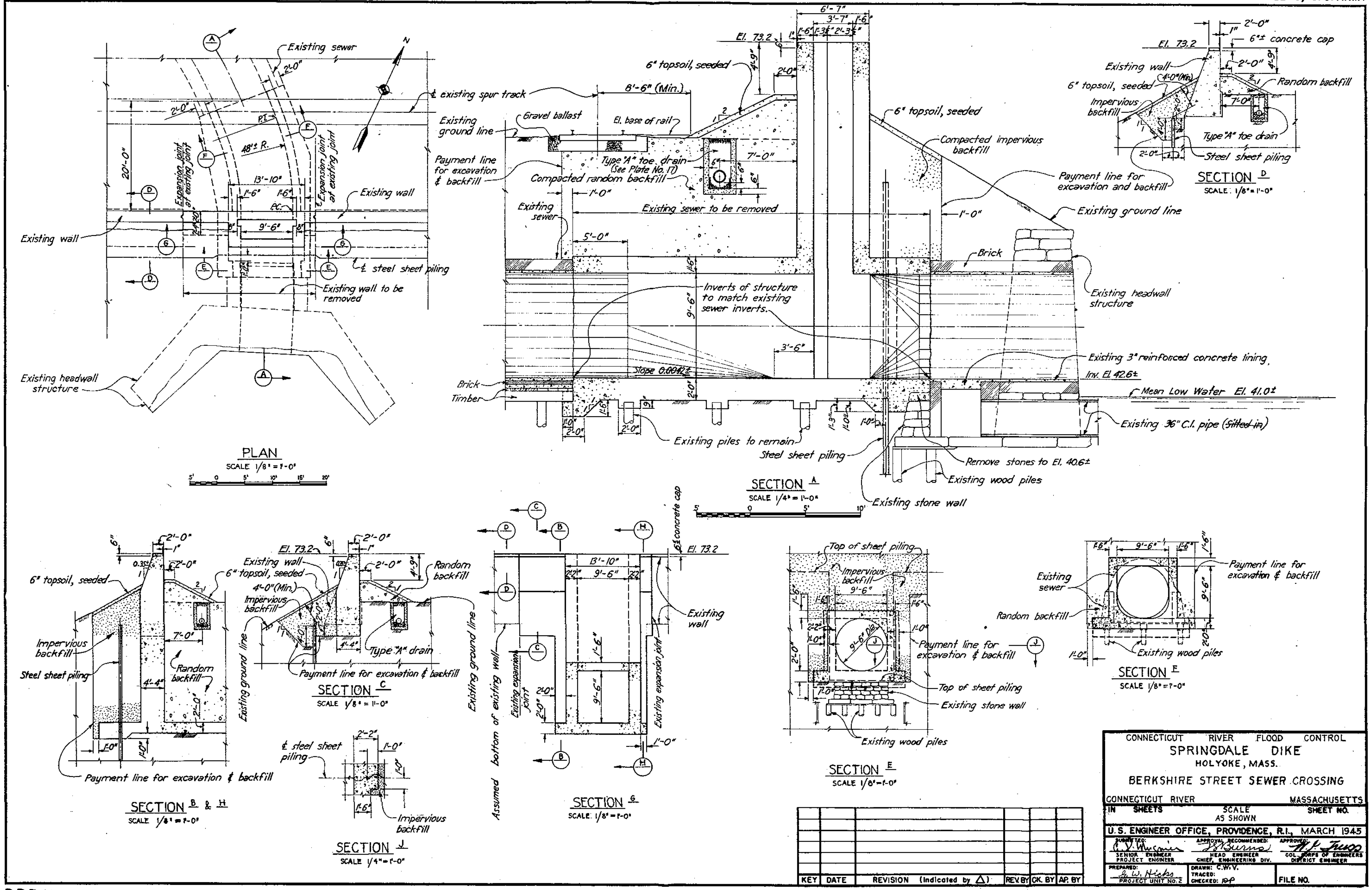


PUMPING CAPACITY

SPRINGDALE PUMPING STATION

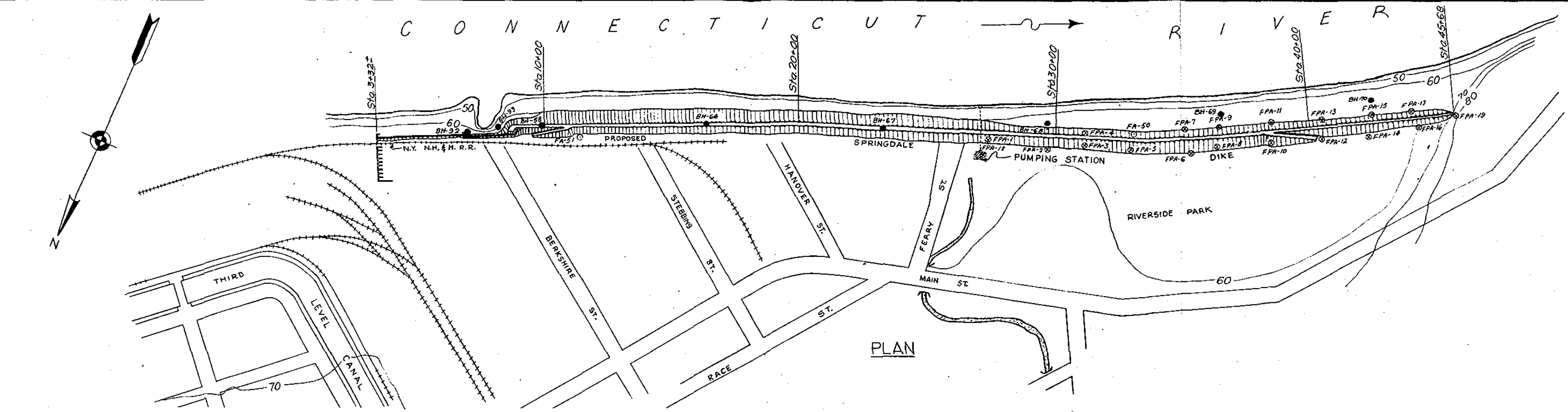
WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

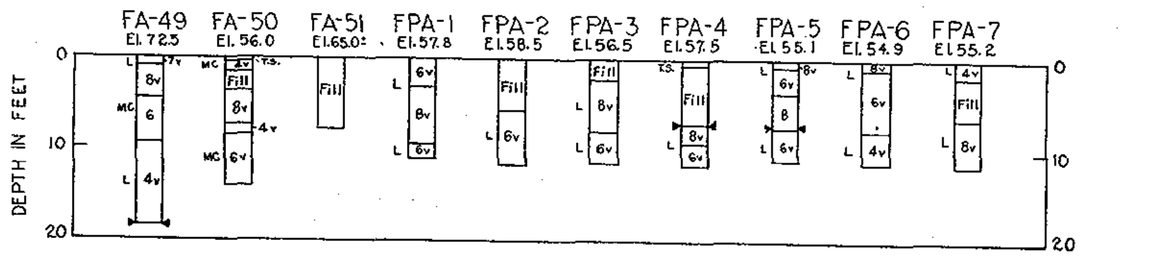


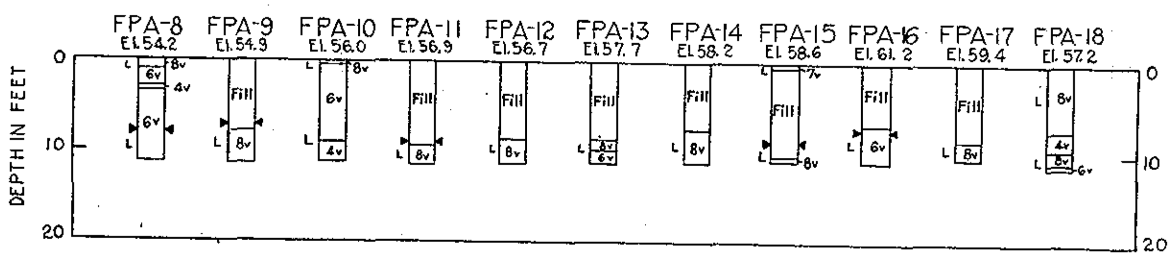
D.P.R. H1.4

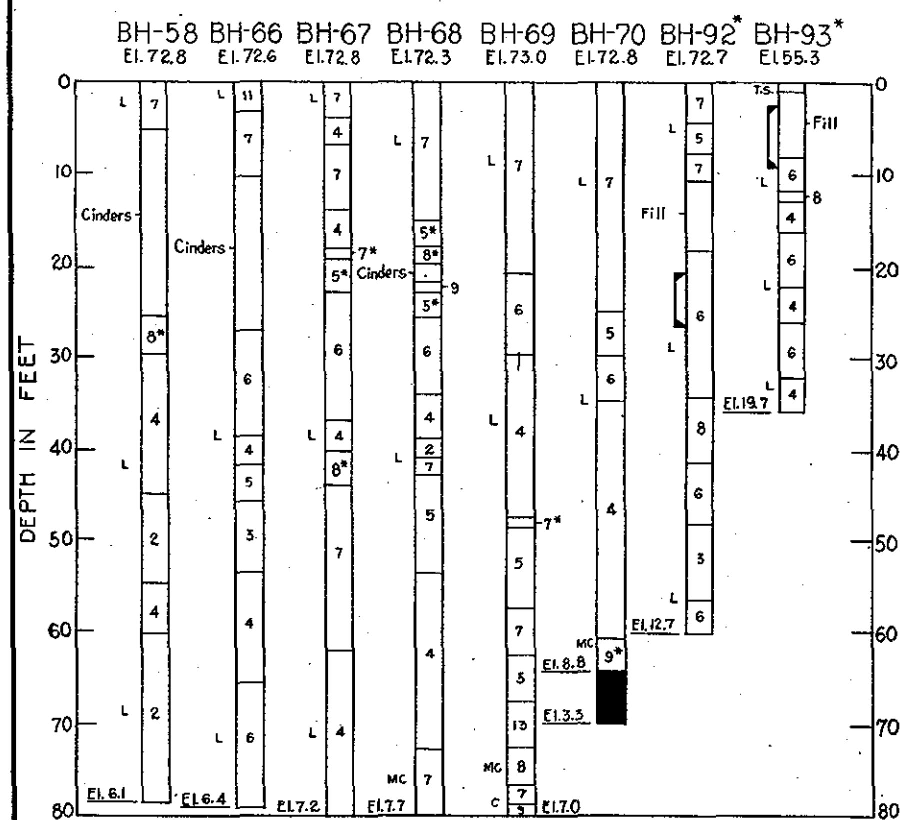
PLATE NO. 23



PLAN







DESCRIPTION OF SOIL CLASSES

1 *Graded from Gravel to Coarse Sand* - Contains little medium sand.

2 *Coarse to Medium Sand* - Contains little gravel and fine sand.

3 *Graded from Gravel to Medium Sand* - Contains little fine sand.

4 *Medium to Fine Sand* - Contains little coarse sand and coarse silt.

5 *Graded from Gravel to Fine Sand* - Contains little coarse silt.

6 *Fine Sand to Coarse Silt* - Contains little medium sand and medium silt.

7 *Graded from Gravel to Coarse Silt* - Contains little medium silt.

8 *Coarse to Medium Silt* - Contains little fine sand and fine silt.

9 *Graded from Gravel to Medium Silt* - Contains little fine silt.

10 *Medium to Fine Silt* - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.

10c *Medium Silt to Coarse Clay* - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.

11 *Graded from Gravel or Coarse Sand to Fine Silt* - Contains little coarse clay.

12 *Fine Silt to Clay* - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.

12c *Clay* - Contains little silt. Possesses behavior characteristics of clay.

13 *Graded from Coarse Sand to Clay* - Contains little fine clay (colloids). Possesses behavior characteristics of silt.

13c *Clay* - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

LEGEND

● BH - *Drive sample bore hole.*
⊙ FA - *Foundation auger boring.*
⊗ FPA - *Foundation power auger boring.*

Av. height of water table during period of observation. Water table - max. and min. during period of observation.
Core recovery - 0-15%.
Core recovery - 16%-50%.
Core recovery - 51%-75%.
Core recovery - 76%-100%.

T.S. *Topsoil*
L - *Loose overburden.* MC - *Medium compact overburden.*
C - *Compact overburden.* VC - *Very compact overburden.*
* *Visual classification.*
M.L.W. - *El. 41.0'*

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
PLAN AND RECORD OF
SUBSURFACE EXPLORATIONS

CONNECTICUT RIVER — MASSACHUSETTS

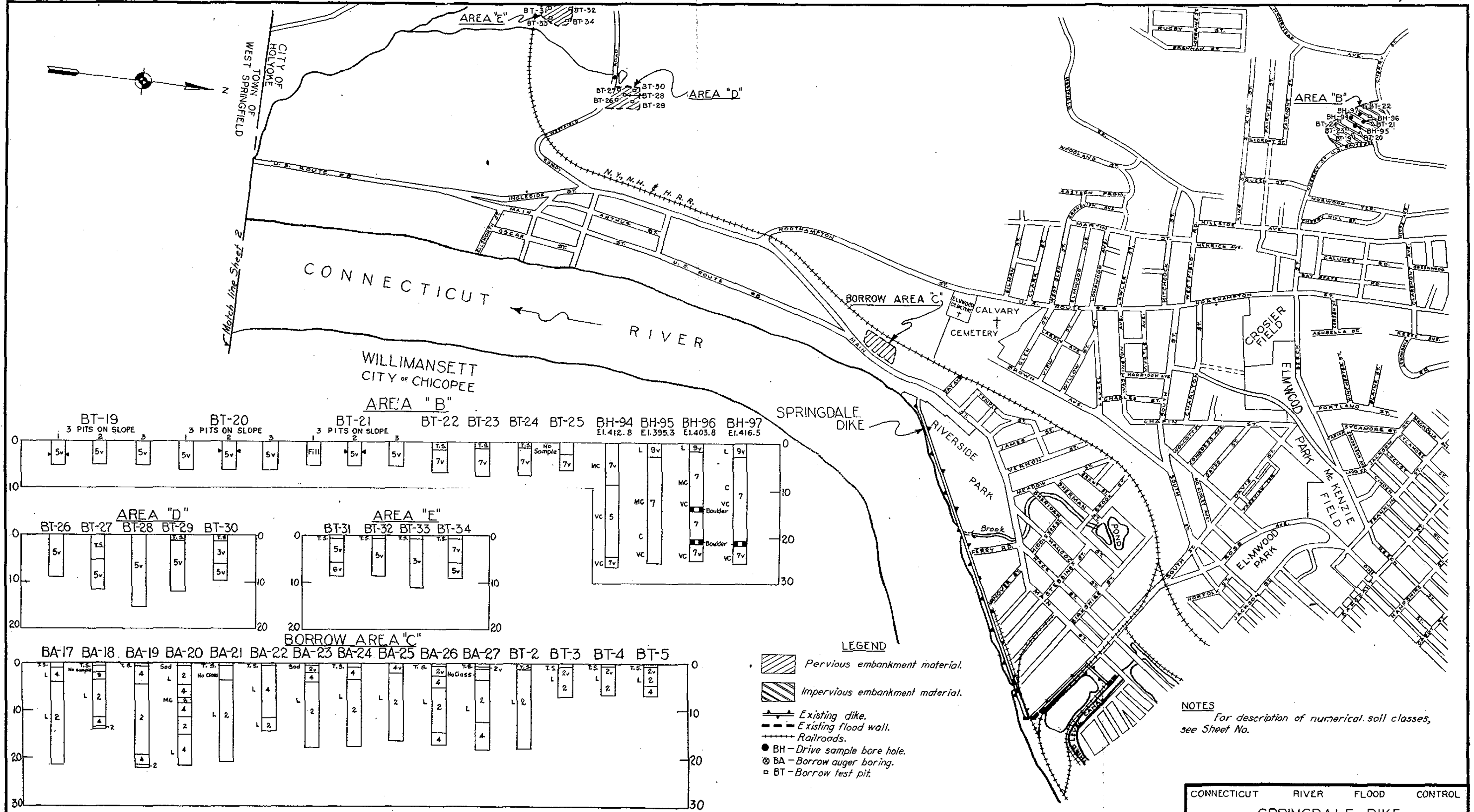
IN SHEETS — SCALE: 1" = 200 FT. — SHEET NO.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

SUBMITTED: SENIOR ENGINEER, HEAD, FOUNDATION INVEST.
APPROVAL RECOMMENDED: HEAD ENGINEER, CHIEF, ENGINEERING DIV.
APPROVED: CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: John Eastwick, FOUND. INVEST. SECTION
DRAWN: A. B. C. W.
TRACED:
CHECKED:
FILE NO.

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



AREA "B" - Area composed of Class 9 material graded from gravel to silt with thick overburden of Class 7 material. Material on face of open pit contains mostly Class 5 material.

BORROW AREA "C" - Permissible borrow area for pervious embankment material. Formation composed chiefly of coarse, medium and fine sand.

AREA "D" - Area composed chiefly of silty gravel with numerous boulders and cobbles.

AREA "E" - Area composed chiefly of silty gravel with few boulders and cobbles.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

PLAN OF BORROW AREAS NO. 1

HOLYOKE MASSACHUSETTS

IN SHEETS SCALE: 1" = 600' SHEET NO.

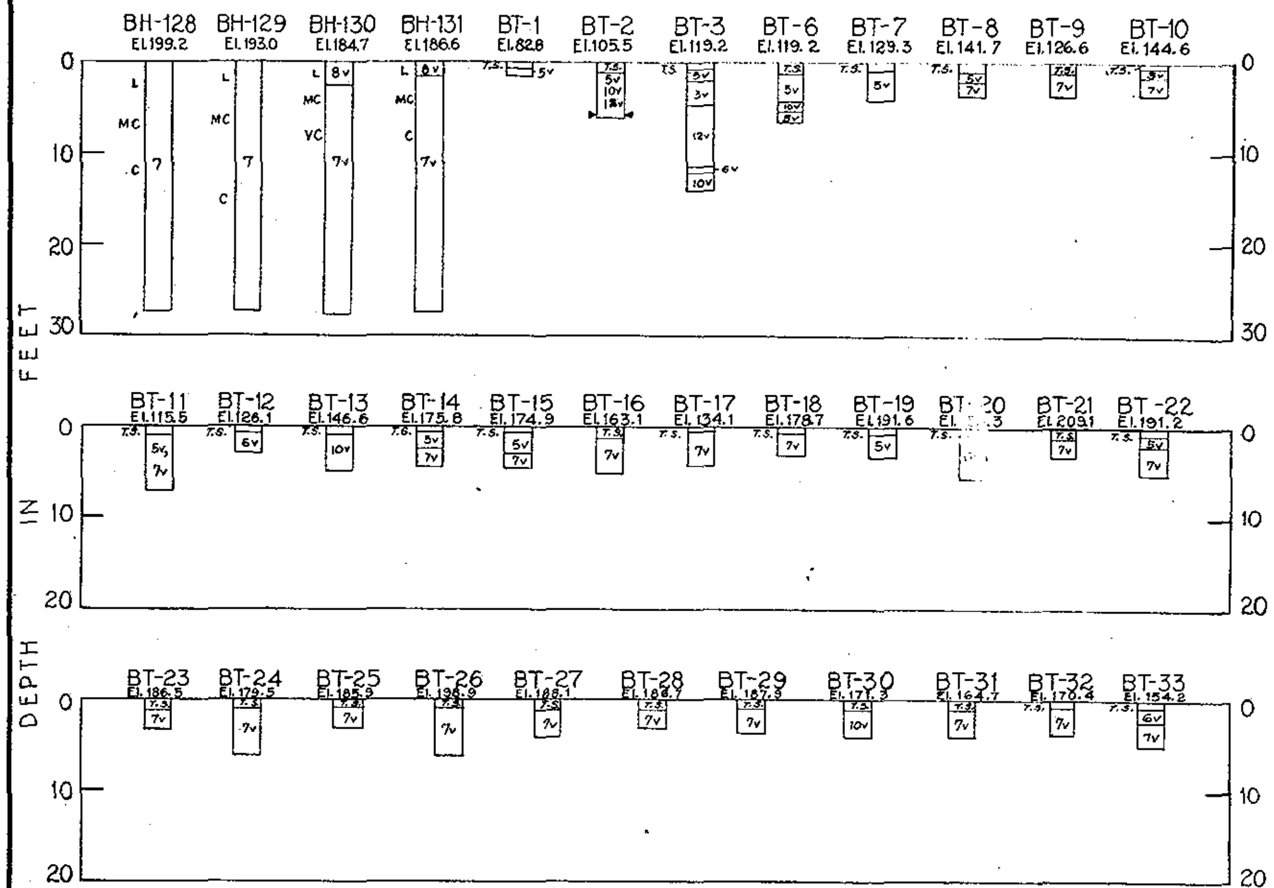
U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

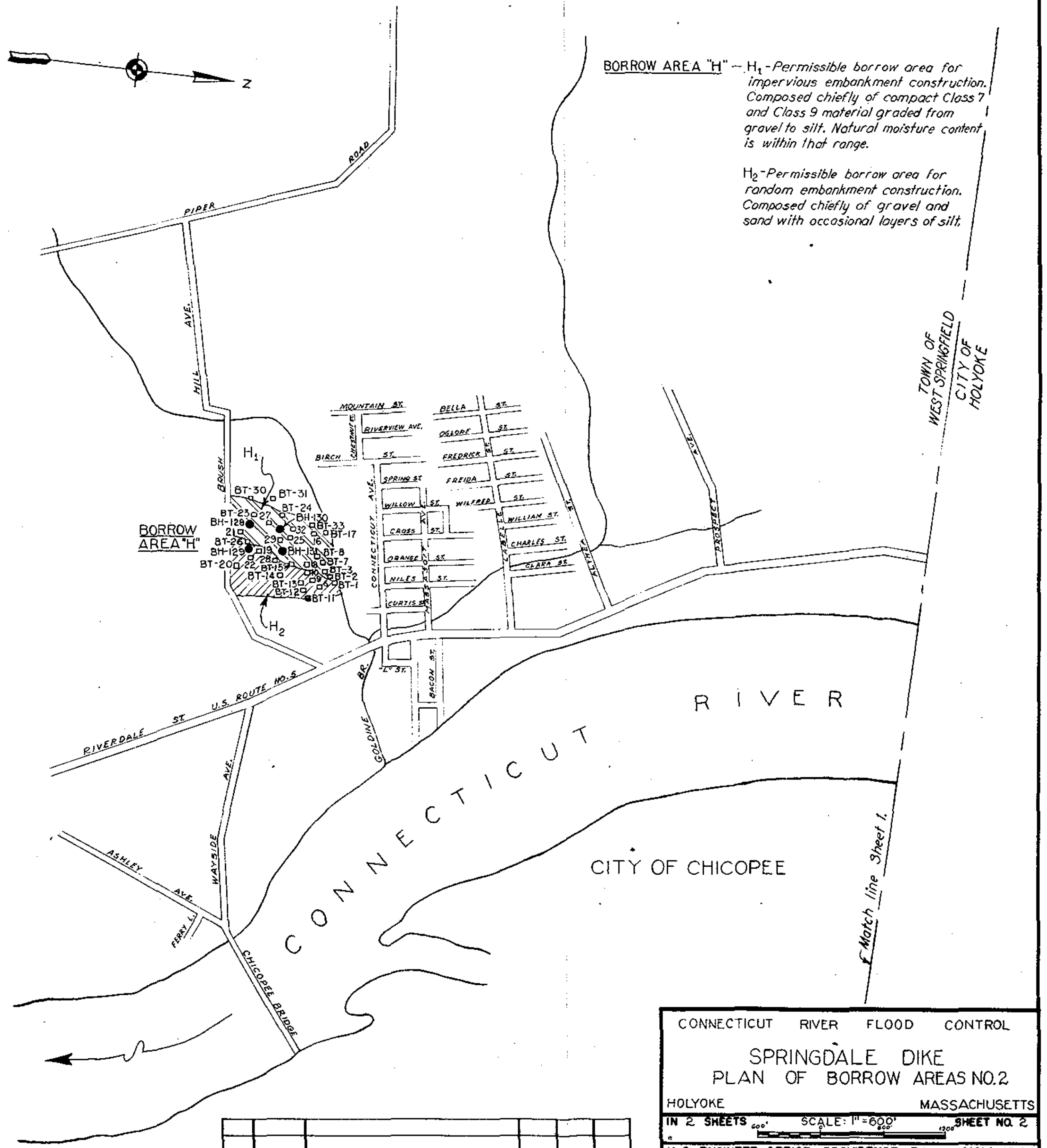
SUBMITTED: SENIOR ENGINEER HEAD, FOUNDATION INVEST. — APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS DISTRICT ENGINEER

PREPARED: John Eastwick FOUNDATION INVEST. SECTION — DRAWN: A. B. C. W. TRACED: CHECKED: — FILE NO.

D.P.R.HI. 4

PLATE NO. 25





BORROW AREA "H" — H_1 - *Permissible borrow area for impervious embankment construction. Composed chiefly of compact Class 7 and Class 9 material graded from gravel to silt. Natural moisture content is within that range.*

H_2 - *Permissible borrow area for random embankment construction. Composed chiefly of gravel and sand with occasional layers of silt.*

● BH - *Drive sample bore hole.*
□ BT - *Borrow test pit.*

NOTES
For general notes, legend and description of numerical soil classes, see Sheet No. 1 - "Subsurface Explorations."

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
PLAN OF BORROW AREAS NO. 2

HOLYOKE MASSACHUSETTS

IN 2 SHEETS SCALE: 1" = 600' SHEET NO. 2

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. NOV., 1944

SUBMITTED: SENIOR ENGINEER FOUNDATION INVEST.
APPROVAL RECOMMENDED: HEAD ENGINEER CHIEF, ENGINEERING DIV.
APPROVED: COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: John Eastwick FOUNDATION INVEST. SECTION
DRAWN: A.B.C.W. TRACED: CHECKED:
FILE NO.

PROVIDENCE DISTRICT SOIL CLASSIFICATION

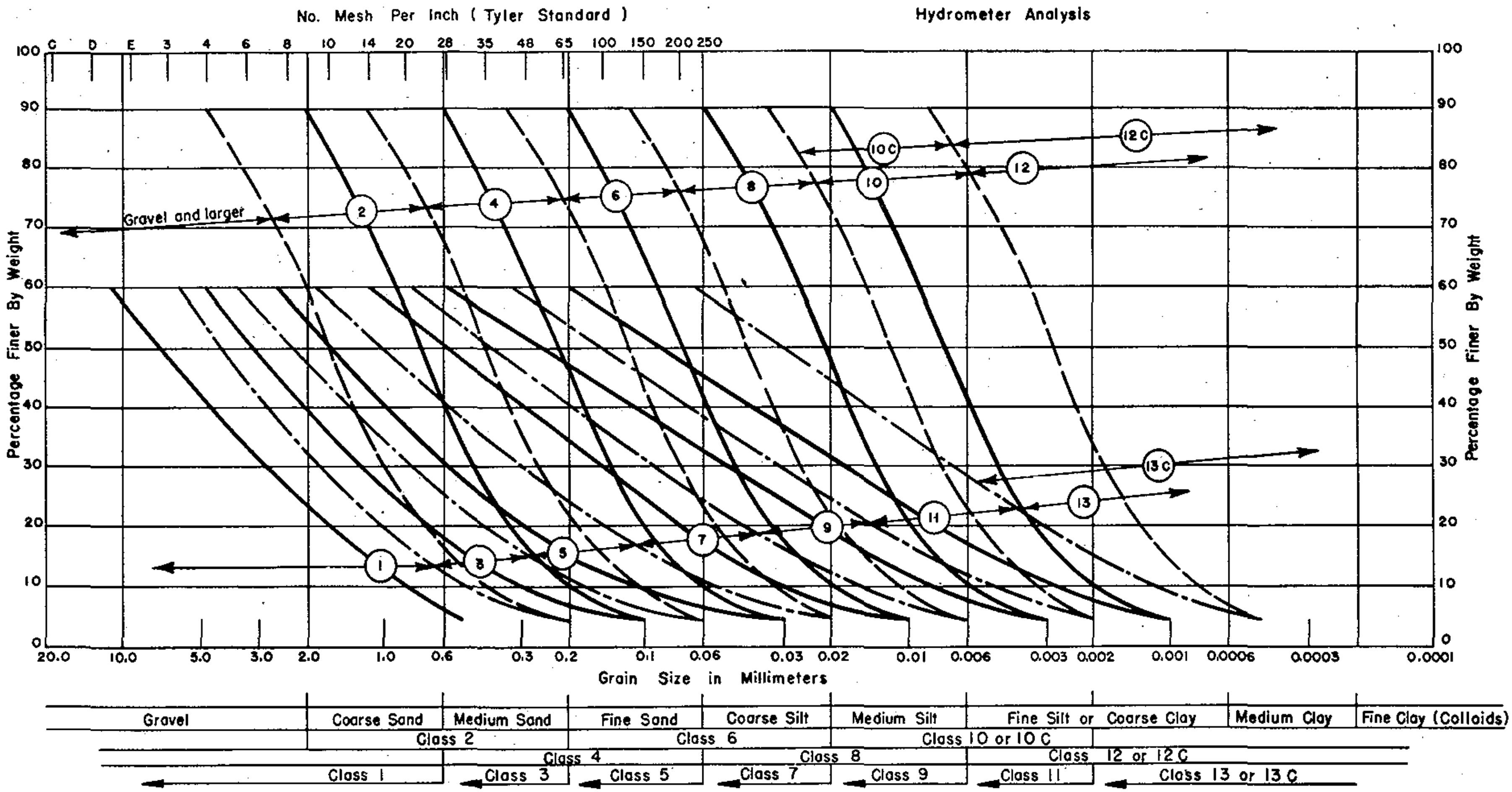
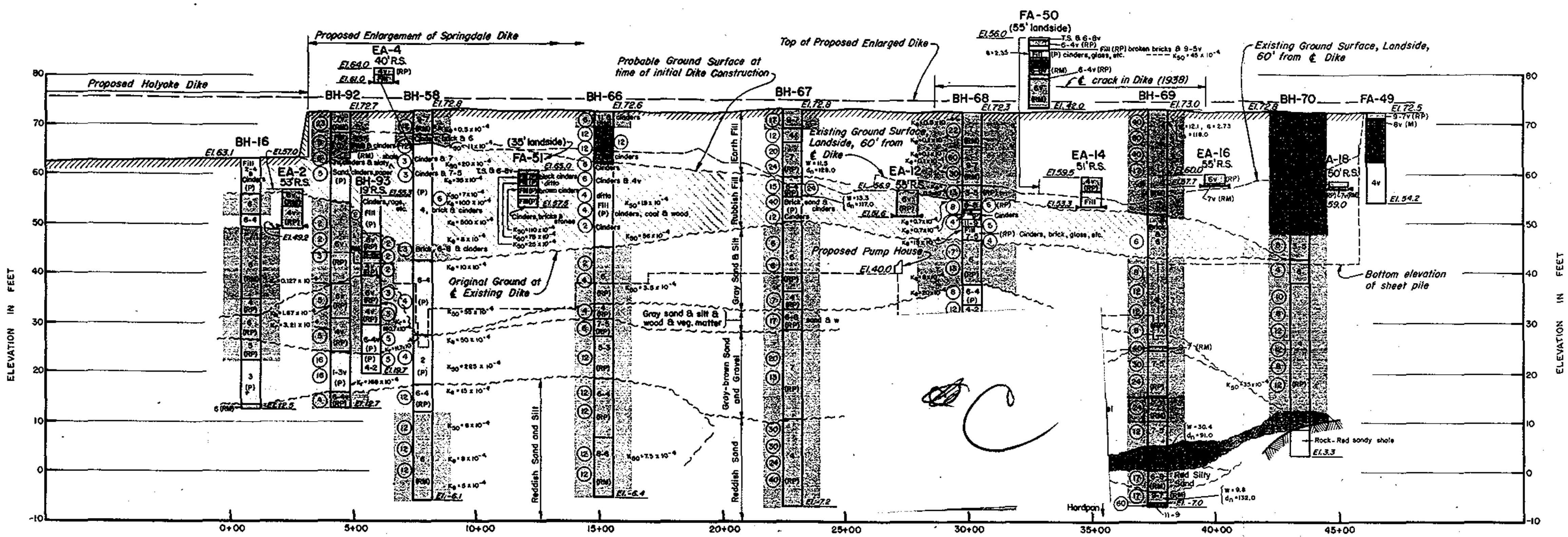


DIAGRAM SHOWING LIMITS OF SOIL CLASSES

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



SOIL PROFILE ON ℄ DIKE

SCALE: HOR. 1" = 200'
VERT. 1" = 10'

LEGEND

- T.S. Topsoil
- 6 Providence Classification
- 6v Visual Classification
- Ground water level
- (5) Penetration in blows per ft. of 350# hammer falling 18" on sampling spoon.

Visual Estimate of Permeability of Soils and Color Legend

- Rubbish Fill
- (P) Pervious ($K > 10.0 \times 10^{-4}$ cms/sec.)
- (RP) Random Pervious ($10.0 \times 10^{-4} > K > 1.0 \times 10^{-4}$ cms/sec.)
- (RM) Random Impervious ($1.0 \times 10^{-4} > K > 0.1 \times 10^{-4}$ cms/sec.)
- (M) Impervious ($K < 0.1 \times 10^{-4}$ cms/sec.)
- Border line soils - Random Impervious and Random Pervious

K_e = Permeability in cm/sec est. by visual inspection, for density ratio = 0.5 ±
K_{50} = Permeability in cm/sec, from test, for density ratio = 0.5 ±
K_r = Permeability in cm/sec from field tests, for spherical flow from end of casing.
K_h = Horizontal permeability in cm/sec from field test.
W = Natural water content, %.
d_n = Natural density, pcf, from paraffined soil cores.

NOTE

Positions of some explorations adjusted horizontally to meet space requirements.

KEY	DATE	REVISION (indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL
SPRINGDALE DIKE
SOIL PROFILE ON ℄ EXISTING DIKE

CONNECTICUT RIVER MASSACHUSETTS

IN SHEETS SCALE: HOR. 1 IN. = 200 FT. VERT. 1 IN. = 10 FT. SHEET NO.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.,

SUBMITTED: K S Lane ENGINEER HEAD, SOILS LABORATORY

SOILS LABORATORY STUDY

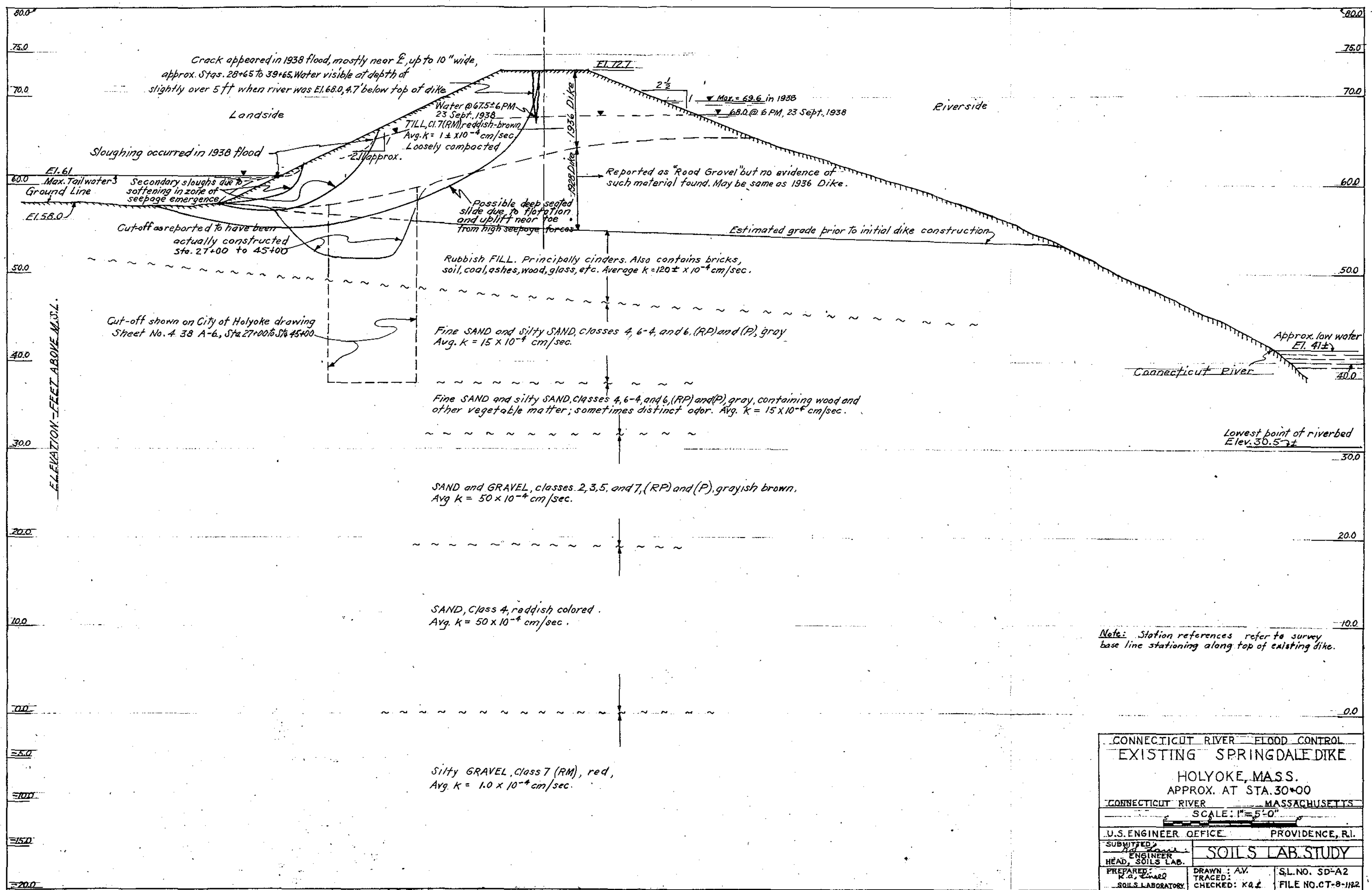
PREPARED: K A Linell ENGINEER

DRAWN: A.J.Z.
TRACED: D.H.R.
CHECKED: A.W.S.

S.L. NO. SD-A1
FILE NO. CT-8-1123

D.P.R. HI. 4

PLATE NO. 28



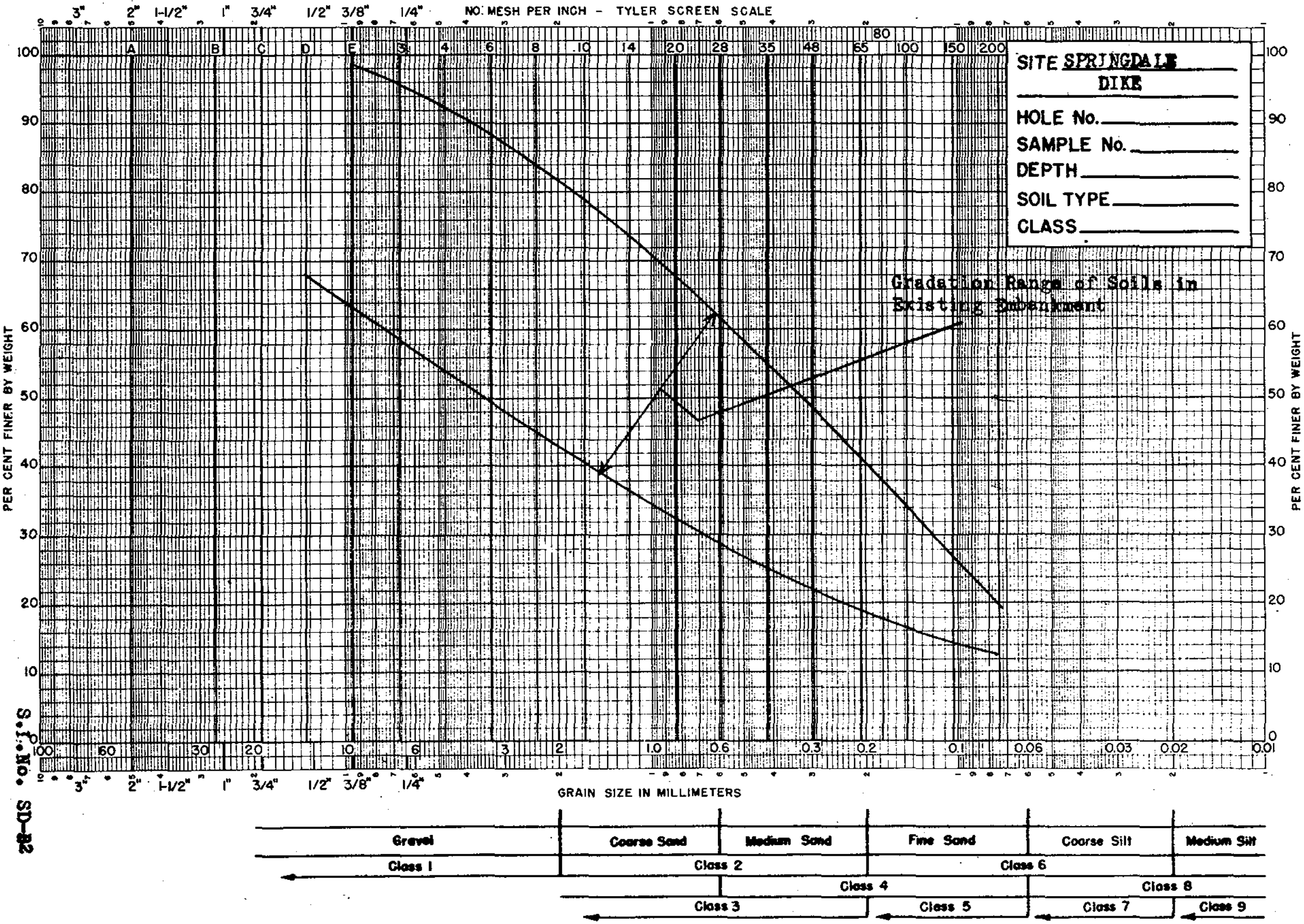
DPR HI. 4

PLATE NO. 29

D.P.R. HI. 4

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



SOILS LABORATORY, ENGINEERING DIVISION

MECHANICAL ANALYSIS

PROVIDENCE, R.I.

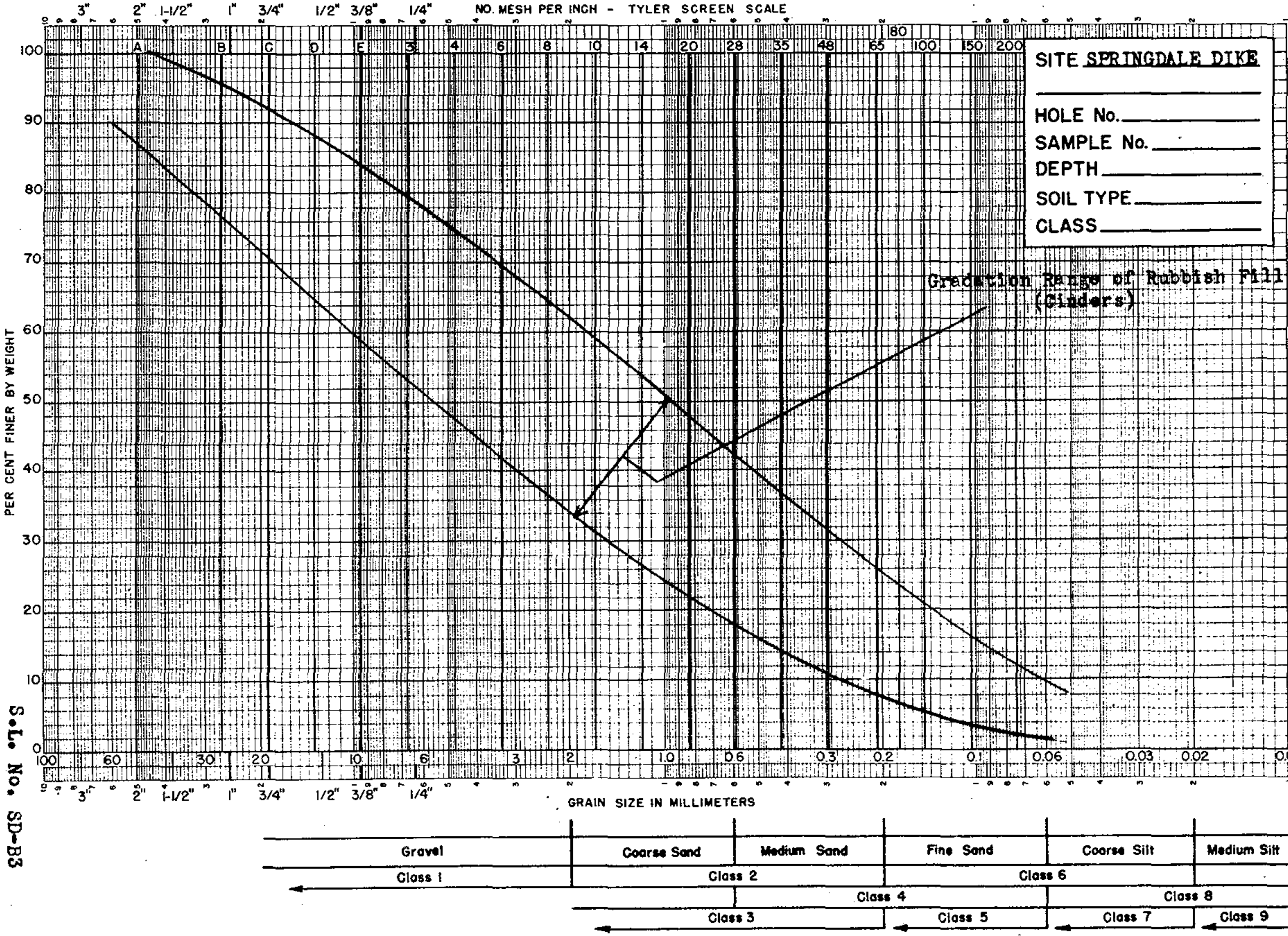
S.I. No. SD-32

PLATE NO. 30

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

D.P.R. HI. 4



S.L. No. SD-B3

PLATE NO. 31

SOILS LABORATORY, ENGINEERING DIVISION

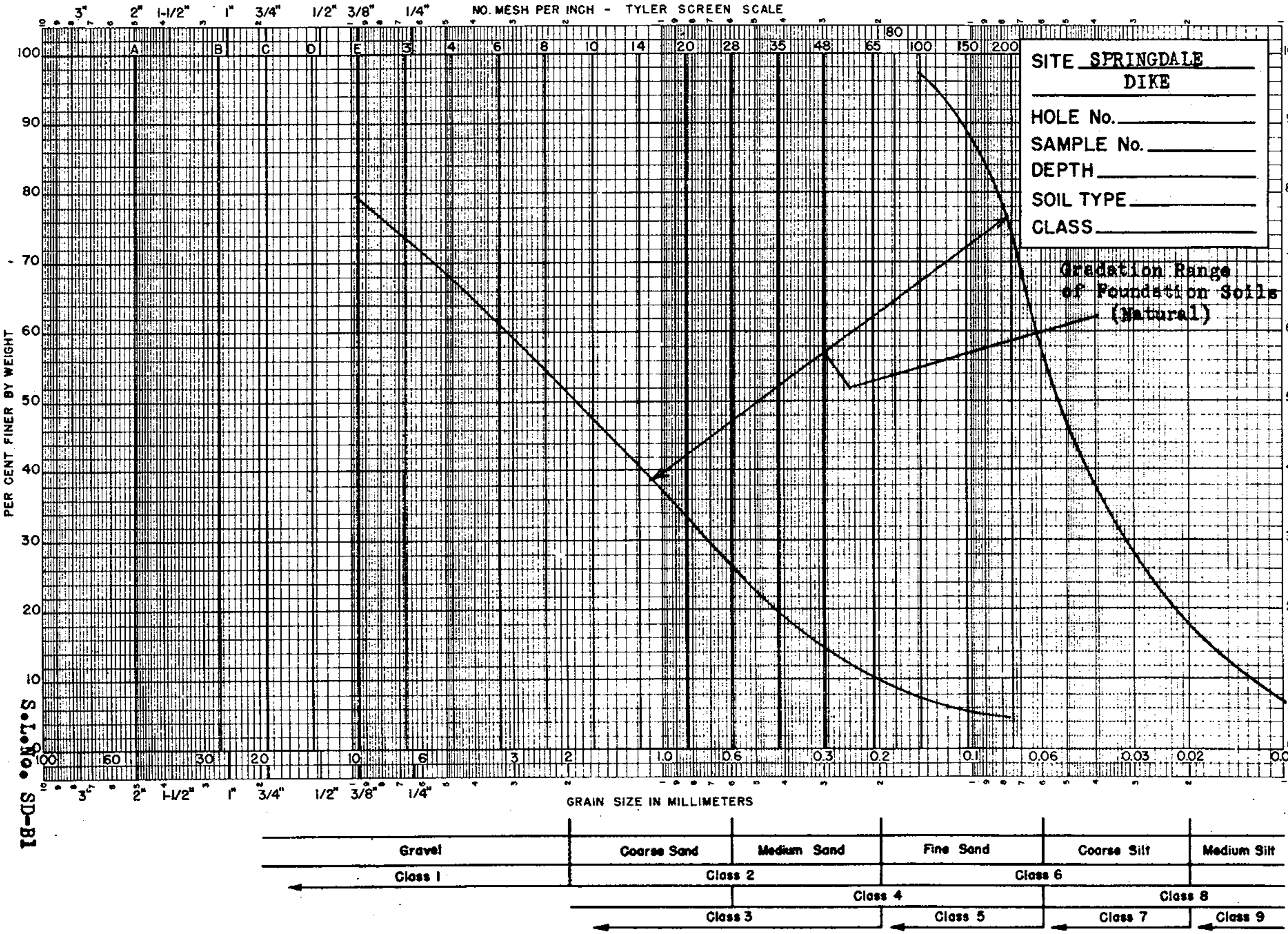
MECHANICAL ANALYSIS

PROVIDENCE, R.I.

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

D.P.R. HI. 4



S.L. No. SD-B1

PLATE NO. 32

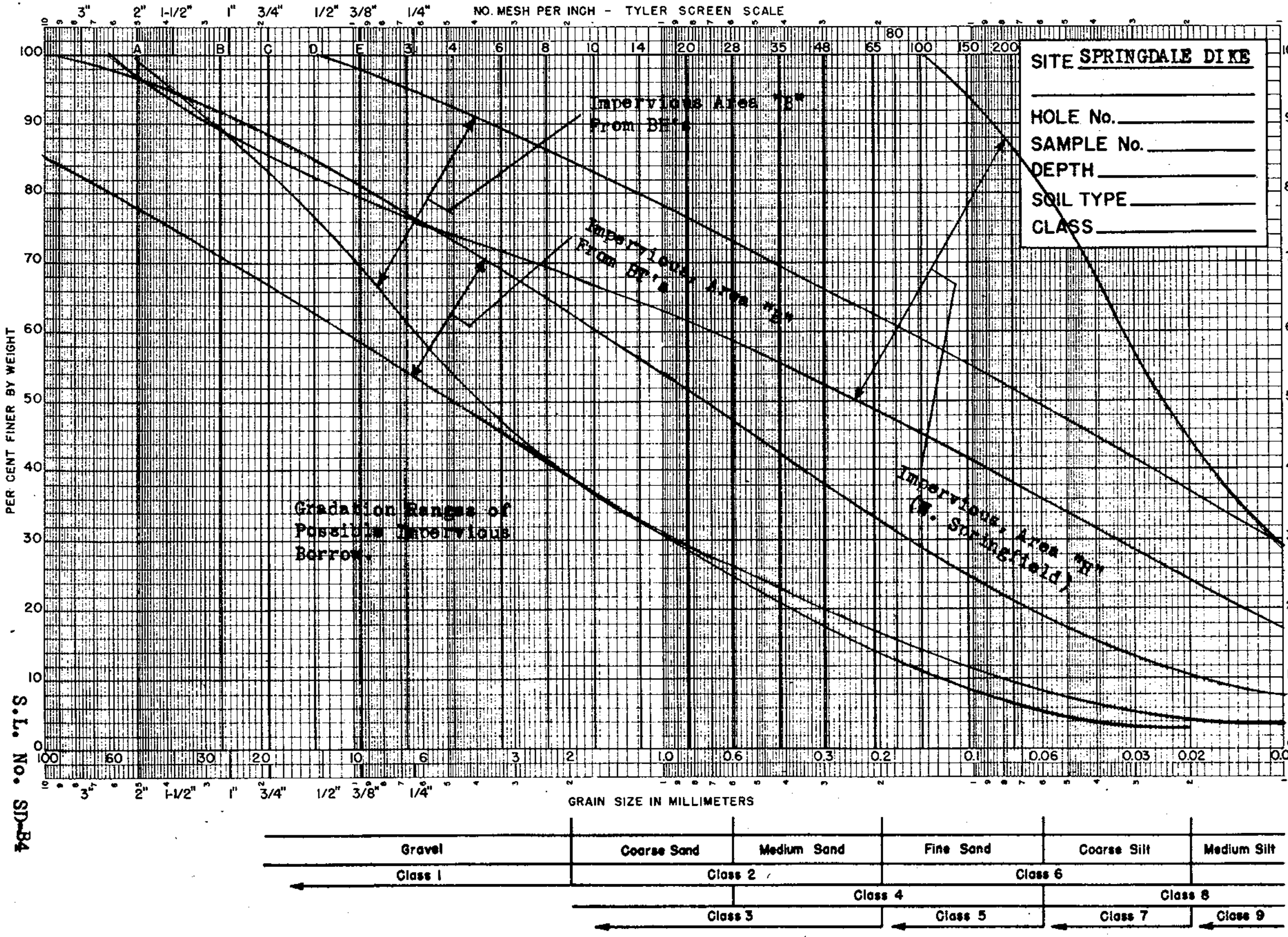
SOILS LABORATORY, ENGINEERING DIVISION

MECHANICAL ANALYSIS

PROVIDENCE, R.I.

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



D.P.R. HI. 4

PLATE NO. 33

S.L. No. SD-B4

SOILS LABORATORY, ENGINEERING DIVISION

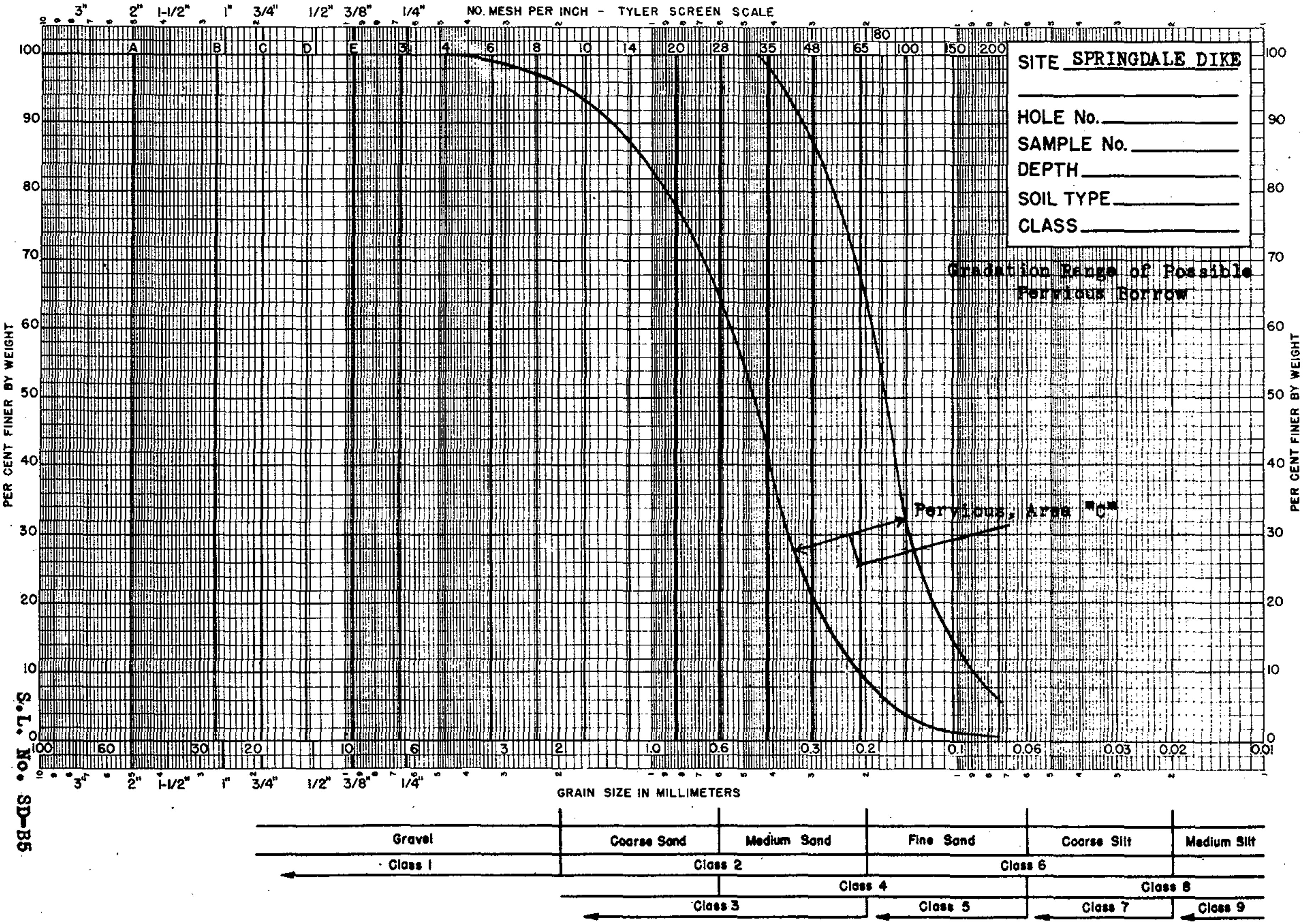
MECHANICAL ANALYSIS

PROVIDENCE, R.I.

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

D.P.R. HI. 4



S.L. No. SD-B5

PLATE NO. 34

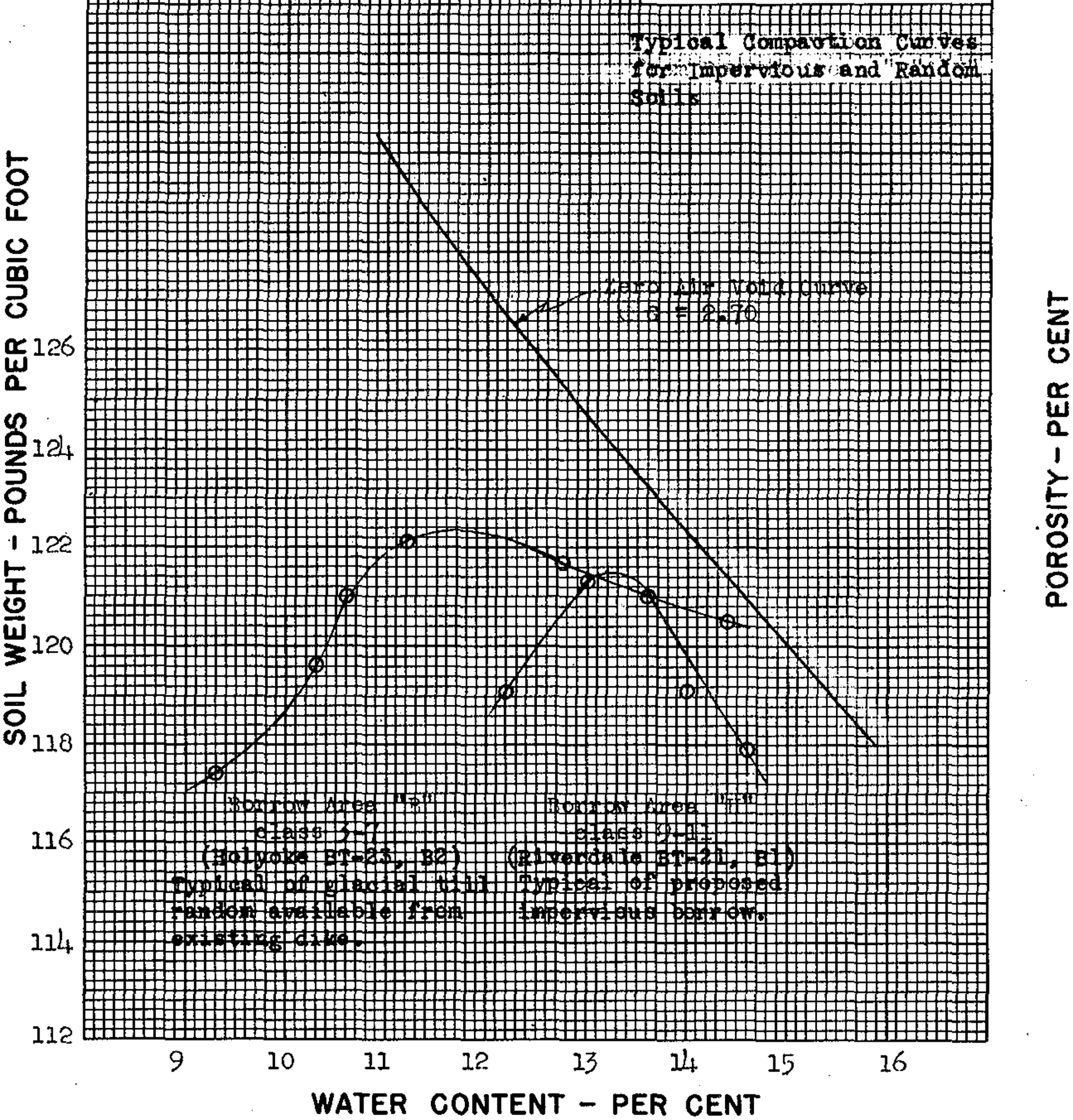
SOILS LABORATORY, ENGINEERING DIVISION

MECHANICAL ANALYSIS

PROVIDENCE, R.I.

COMPACTION CHARACTERISTICS

SITE SPRINGDALE DIKE
HOLE NO. ______
DEPTH ______
SAMPLE NO. ______



Class As shown

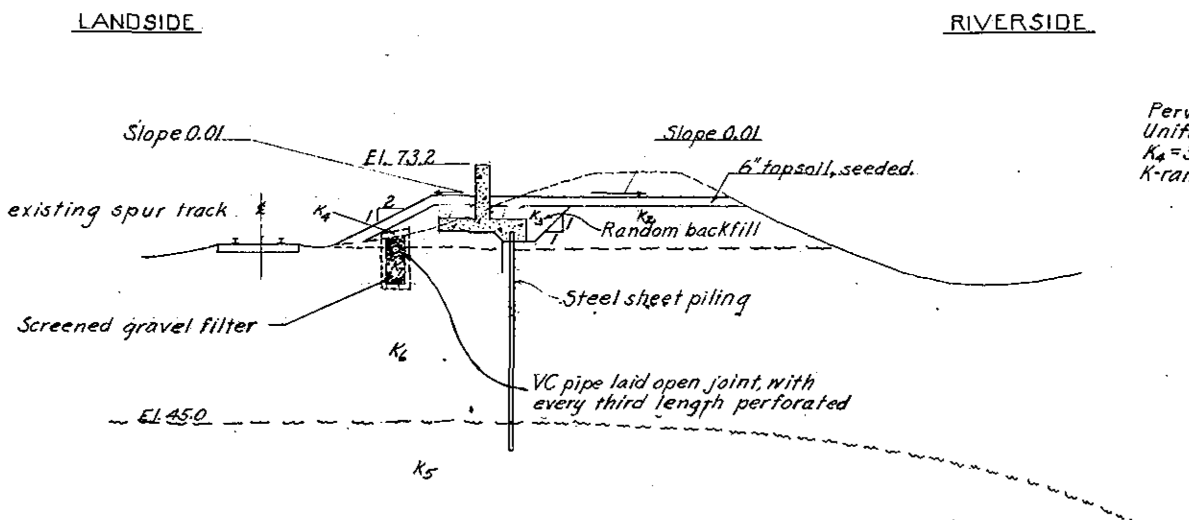
MATERIAL SCREENED OUT

Minimum Size, mm. --
Per Cent by weight --

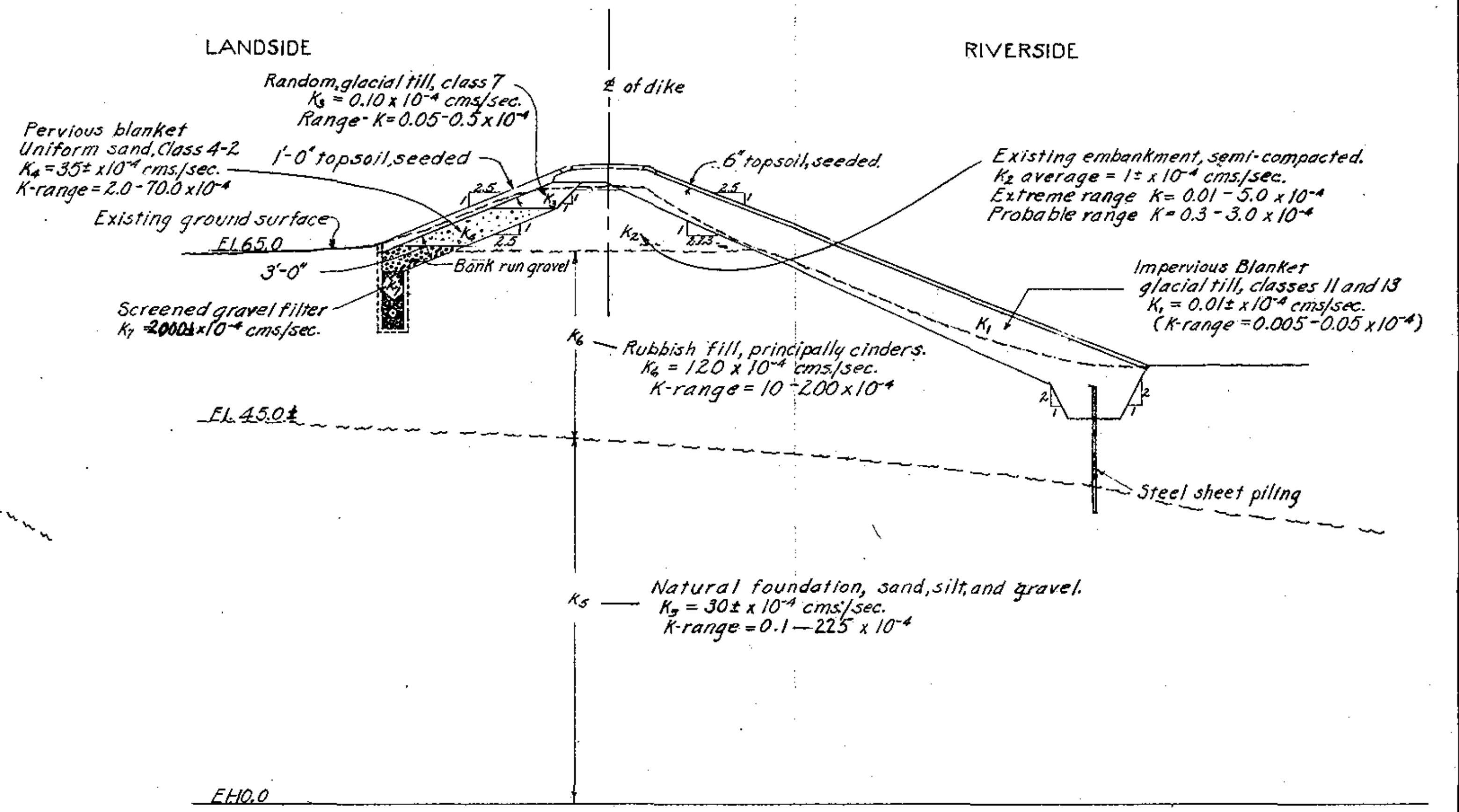
No. Blows/Layer 56
Area of Tamper, sq. in. 3.14
Weight of Tamper, lbs. 5.5
Fall of Tamper, in. 12

S.L.No. SD-C1

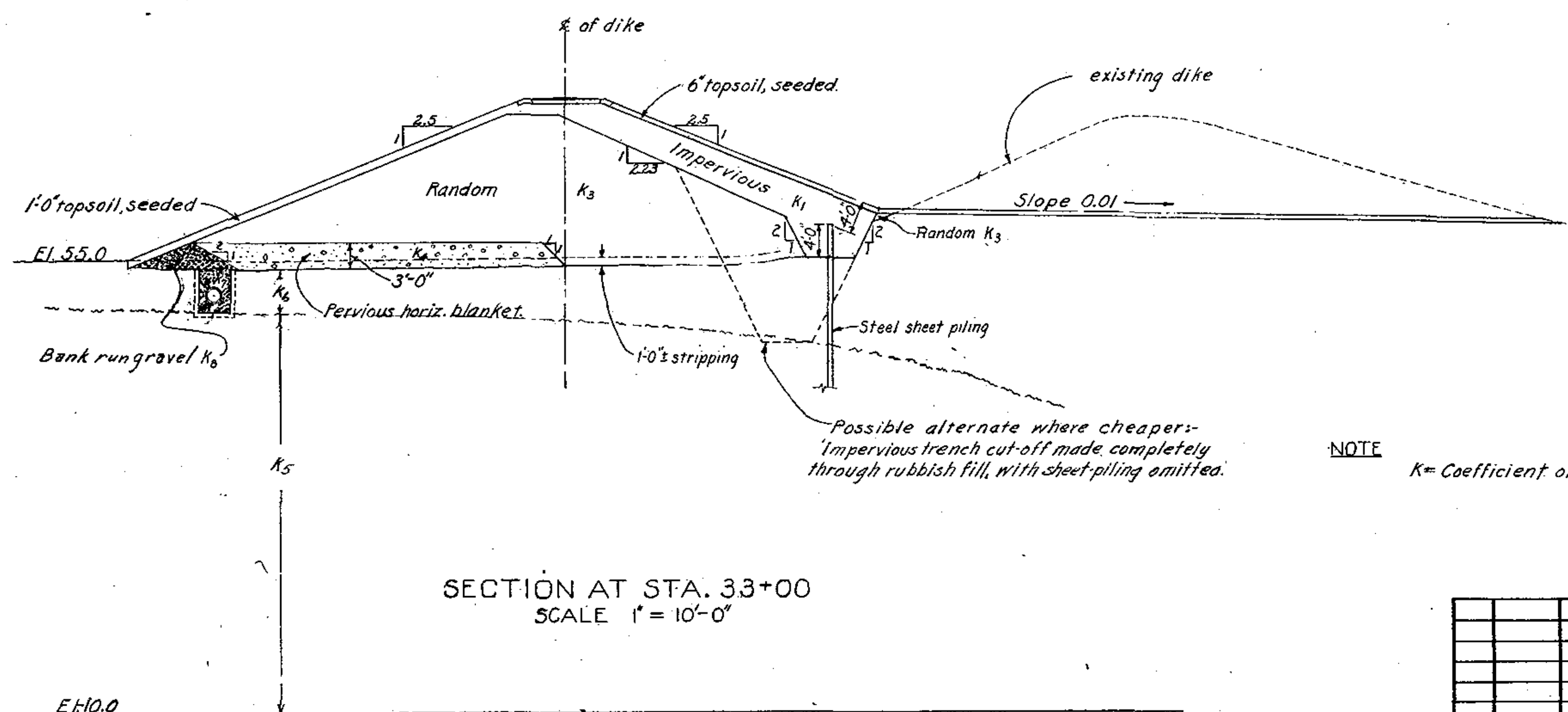
U.S. GOVERNMENT PRINTING OFFICE : 1939--O-146027



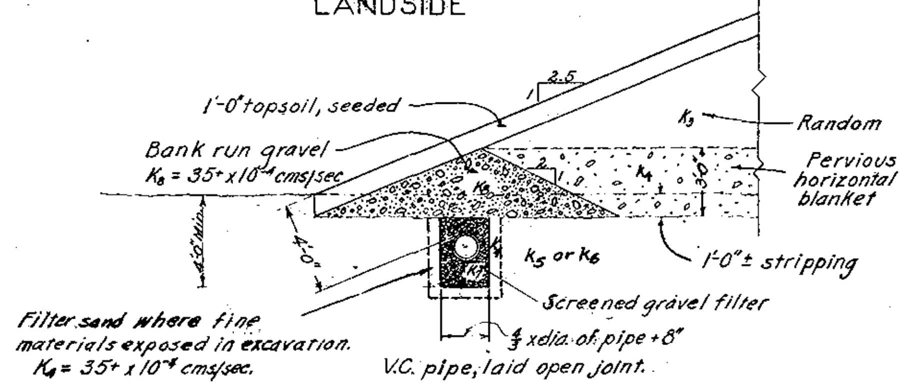
SECTION AT STA. 6+00
SCALE 1" = 10'-0"



SECTION AT STA. 17+00
SCALE 1" = 10'-0"



SECTION AT STA. 33+00
SCALE 1" = 10'-0"



TYPE "C" TOE DRAIN
TYPICAL FROM STA. 37+60 TO STA. 45+05
SCALE 1/4" = 1'-0"

NOTE

K = Coefficient of Permeability, cms/sec. @ 10°C. (50°F)

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE

PERMEABILITIES ASSUMED FOR DESIGN STUDIES

CONNECTICUT RIVER, HOLYOKE, MASS.

IN 1 SHEETS — SCALE: 1 IN = 10 FT. — SHEET NO. 1

U. S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

SUBMITTED: SENIOR ENGINEER, HEAD, SOILS LAB.

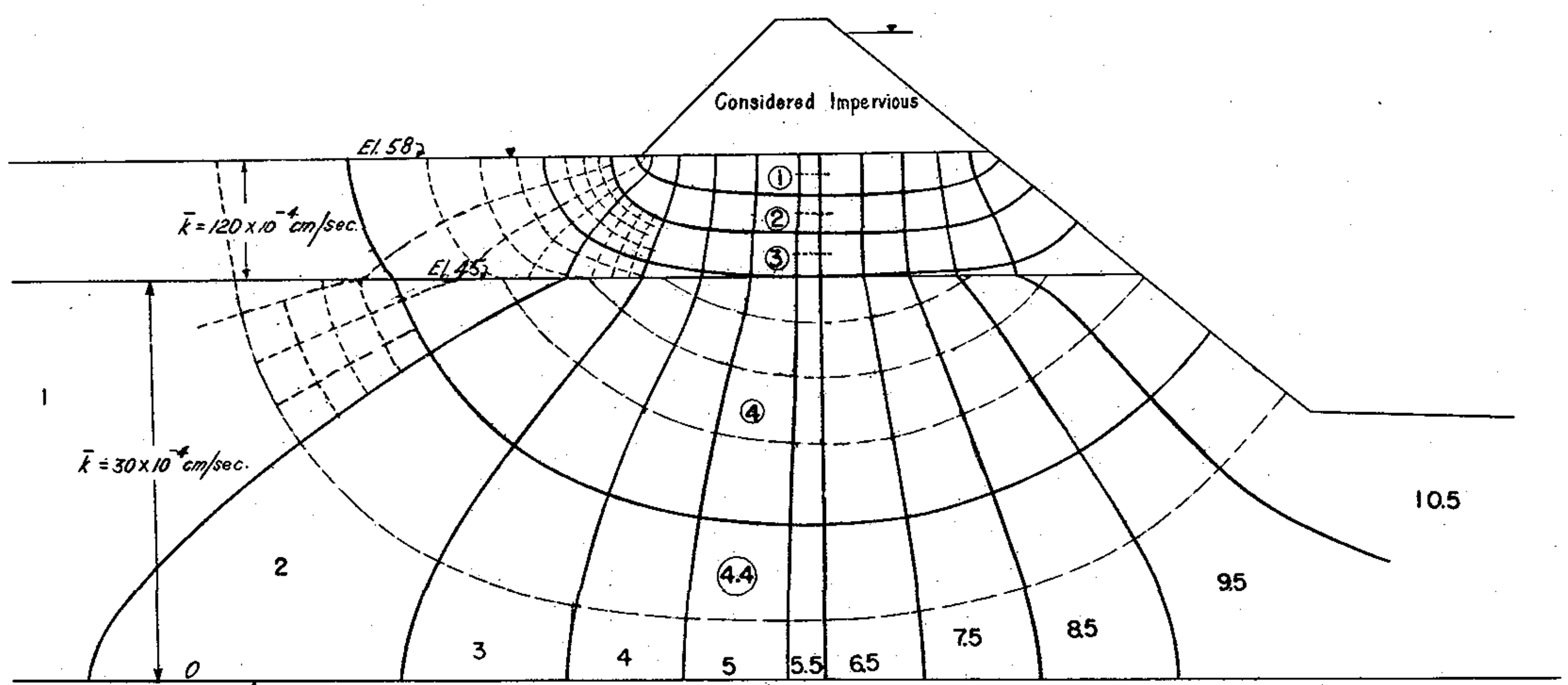
SOILS LABORATORY STUDY

DRAWN: — TRACED: — CHECKED:

S.L. No. SD-A3

FILE NO.

Transformed Section



Scale:
Horiz: 1" = 20'
Vert: 1" = 10'

Assumptions
$k_H = 4 k_V$
$h = 5$ ft.
Transformation factor $= \sqrt{1/4} = 1/2$

Results: shape factor $= \frac{n_f}{n_e} = \frac{4.4}{10.5} = 0.419$

Quantity $= k h \frac{n_f}{n_e} \left(\frac{120 \times 10^{-4}}{30}\right)(5)(0.419) = 8.38 \times 10^{-4}$ cfs/ft.

Q Total $= (4300)(8.38) \times 10^{-4} = 3.60$ c.f.s.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

SPRINGDALE DIKE
SEEPAGE STUDY
1938 Conditions

IN 1 SHEETS — SCALE: 1 IN. = 20 FT. — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., NOV. 1944

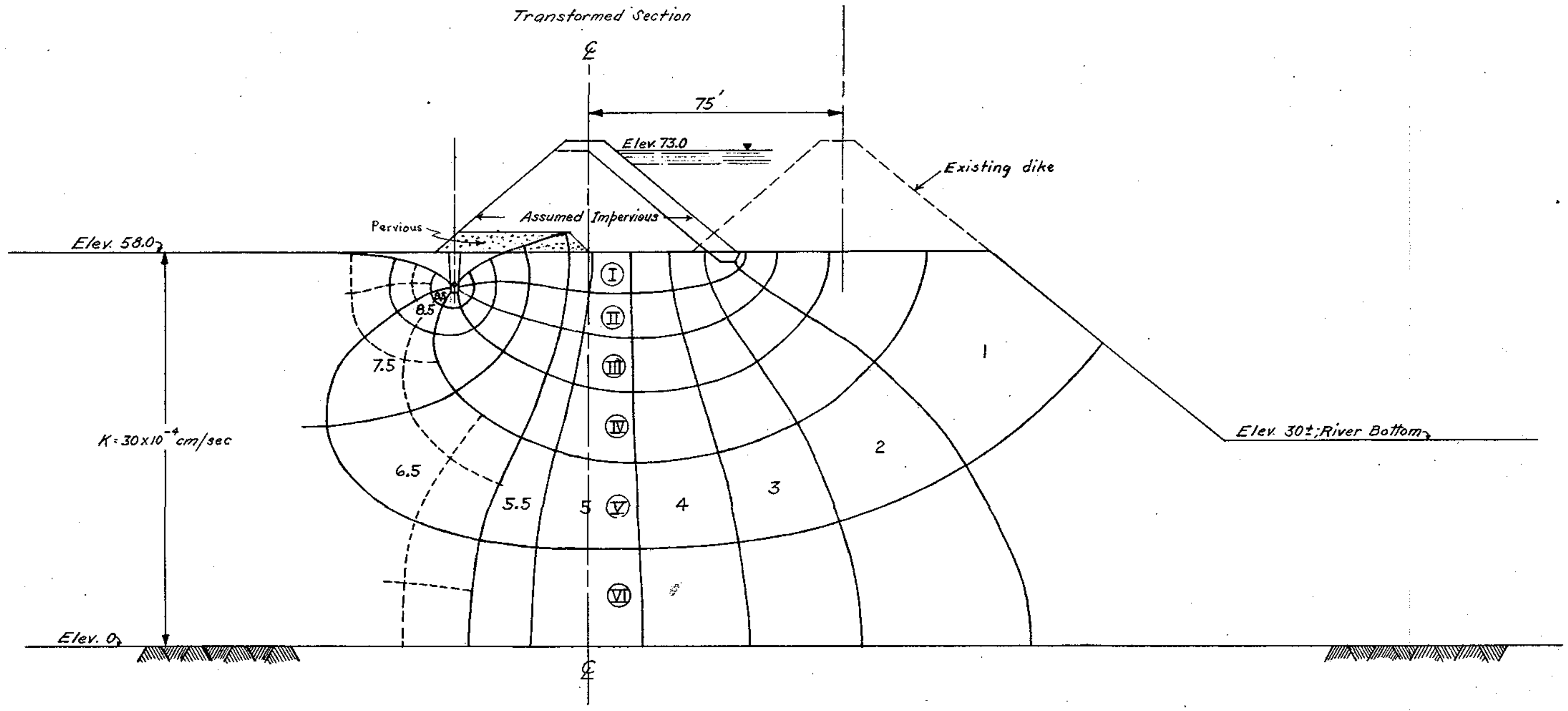
SUBMITTED: *K S Lane* ENGINEER, HEAD, SOILS LABORATORY

SOILS LABORATORY STUDY

PREPARED: *K. A. Linell* SOILS LABORATORY

DRAWN: A.W.B. & A.V. TRACED: R.C.W. CHECKED:

S.L. No. SD-81
FILE NO.



SCALE
Horiz : 1" = 20'
Vert : 1" = 10'

Results : shape factor $= \frac{n_f}{n_e} = \frac{6}{9.5} = 0.632$

Quantity $= k\,h\,\frac{n_f}{n_e} = \left(\frac{30 \times 10^{-4}}{30.5}\right)(20)(0.632) = 0.00124$ cfs/ft

$Q_{TOTAL} = (4300)(0.00124) = 5.3$ cfs

Assumptions:

$K_H = 4 K_V$

$h = 20'$

Transformation factor $= \sqrt{\frac{1}{4}} = \frac{1}{2}$

Invert of drain @ depth 5'

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

SPRINGDALE DIKE
SEEPAGE STUDY
CASE WITH TRENCH CUT-OFF

IN 1 SHEETS — SCALE: 1 IN. = 20 FT. — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

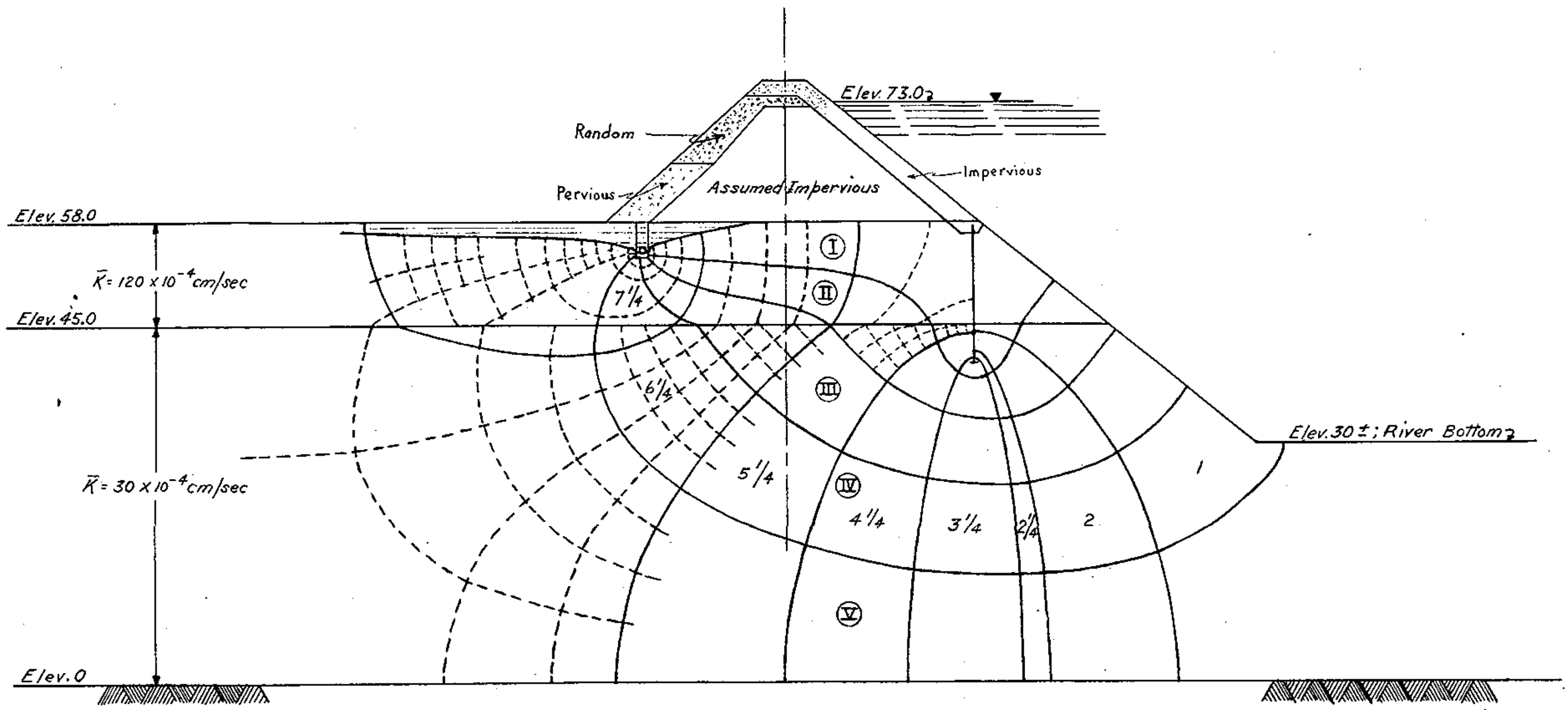
SUBMITTED: K. S. Lane, SR. ENGINEER, HEAD, SOILS LABORATORY

SOILS LABORATORY STUDY

PREPARED: K. A. Linell, SOILS LABORATORY

DRAWN: A.V.
TRACED:
CHECKED: KAL

SL. NO. SD-E2
FILE NO.



SCALE
Horiz: 1" = 20'
Vert: 1" = 10'

Results: Shape Factor $= \frac{n_f}{n_e} = \frac{5}{7.25} = 0.690$

Quantity: $Q = Kh\frac{n_f}{n_e} = \frac{(30)(19)(0.690)(10^{-4})}{30.5} = 0.0013$ cf/sec/ft

Q_{TOTAL} $= (4300)(0.0013) = 5.6$ cf/sec.

Assumptions

$K_H = 4K_V$

$h = 19'$

Transformation Factor $= \sqrt{\frac{1}{4}} = \frac{1}{2}$

Invert of drain @ depth of 4'

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

SPRINGDALE DIKE

SEEPAGE STUDY

CASE WITH SHEET PILE

IN 1 SHEETS SCALE: 1 IN. = 20 FT. SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1945

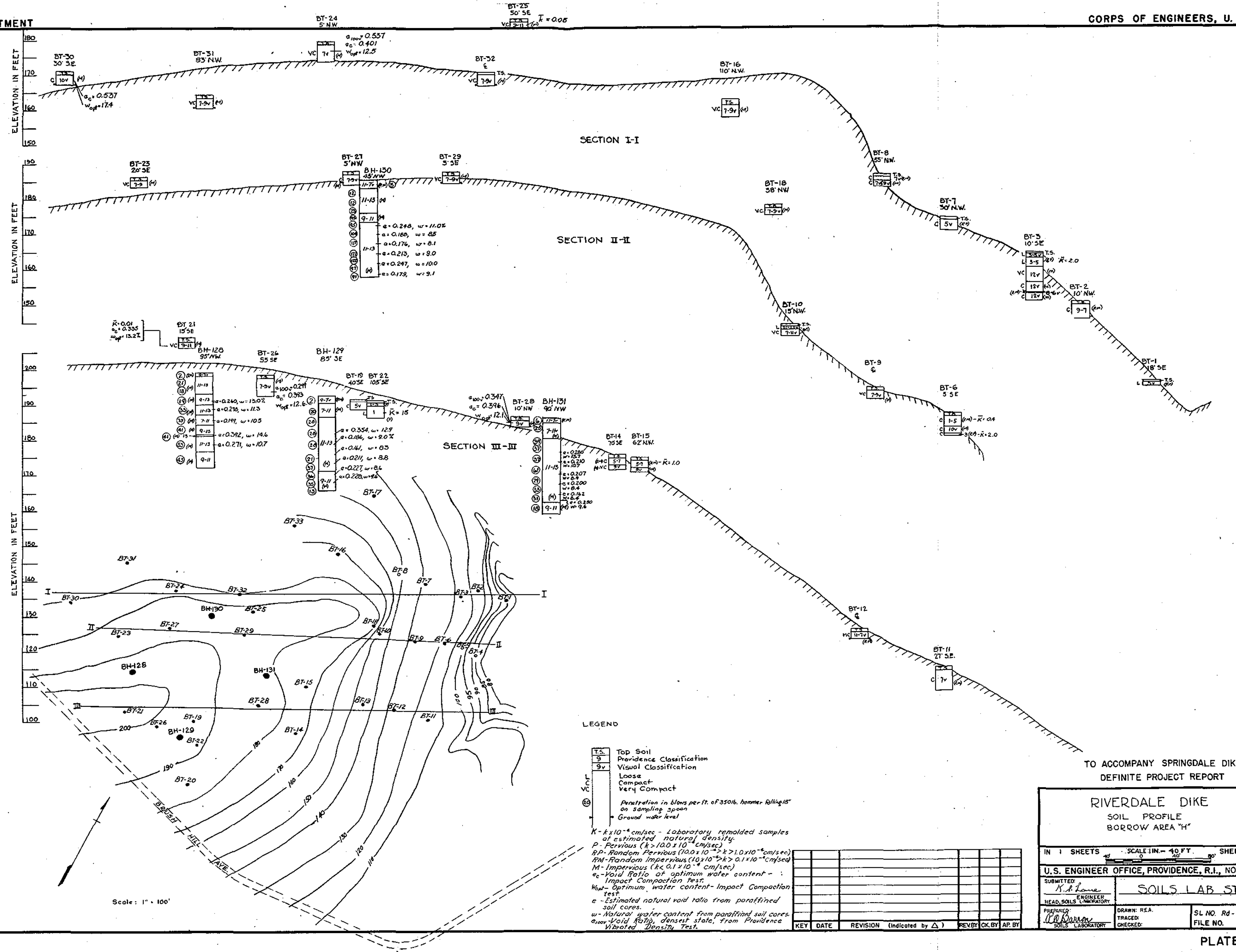
SUBMITTED: K S Rowe
SR. ENGINEER
HEAD, SOILS LABORATORY

SOILS LABORATORY STUDY

PREPARED: K. A. Fiedl
SOILS LABORATORY

DRAWN: A.V.
TRACED:
CHECKED: Ka L

SL. NO. SD-E3
FILE NO.



LEGEND

T.S. Top Soil
9 Providence Classification
9v Visual Classification
L Loose
C Compact
VC Very Compact
(20) Penetration in blows per ft. of 350 lb. hammer falling 18" on sampling spoon
Ground water level

K - $k \times 10^{-4}$ cm/sec - Laboratory remolded samples at estimated natural density.
P - Pervious ($k > 10.0 \times 10^{-4}$ cm/sec)
RP - Random Pervious ($10.0 \times 10^{-4} > k > 1.0 \times 10^{-4}$ cm/sec)
RM - Random Impervious ($1.0 \times 10^{-4} > k > 0.1 \times 10^{-4}$ cm/sec)
M - Impervious ($k < 0.1 \times 10^{-4}$ cm/sec)
e_c - Void Ratio at optimum water content - Impact Compaction test.
W_{opt} - Optimum water content - Impact Compaction test.
e - Estimated natural void ratio from paraffined soil cores.
w - Natural water content from paraffined soil cores.
e_{100V} - Void Ratio, densest state, from Providence Vibrated Density Test.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

TO ACCOMPANY SPRINGDALE DIKE
DEFINITE PROJECT REPORT

RIVERDALE DIKE
SOIL PROFILE
BORROW AREA "H"

IN 1 SHEETS — SCALE 1 IN. = 40 FT. — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., NOV. 1944

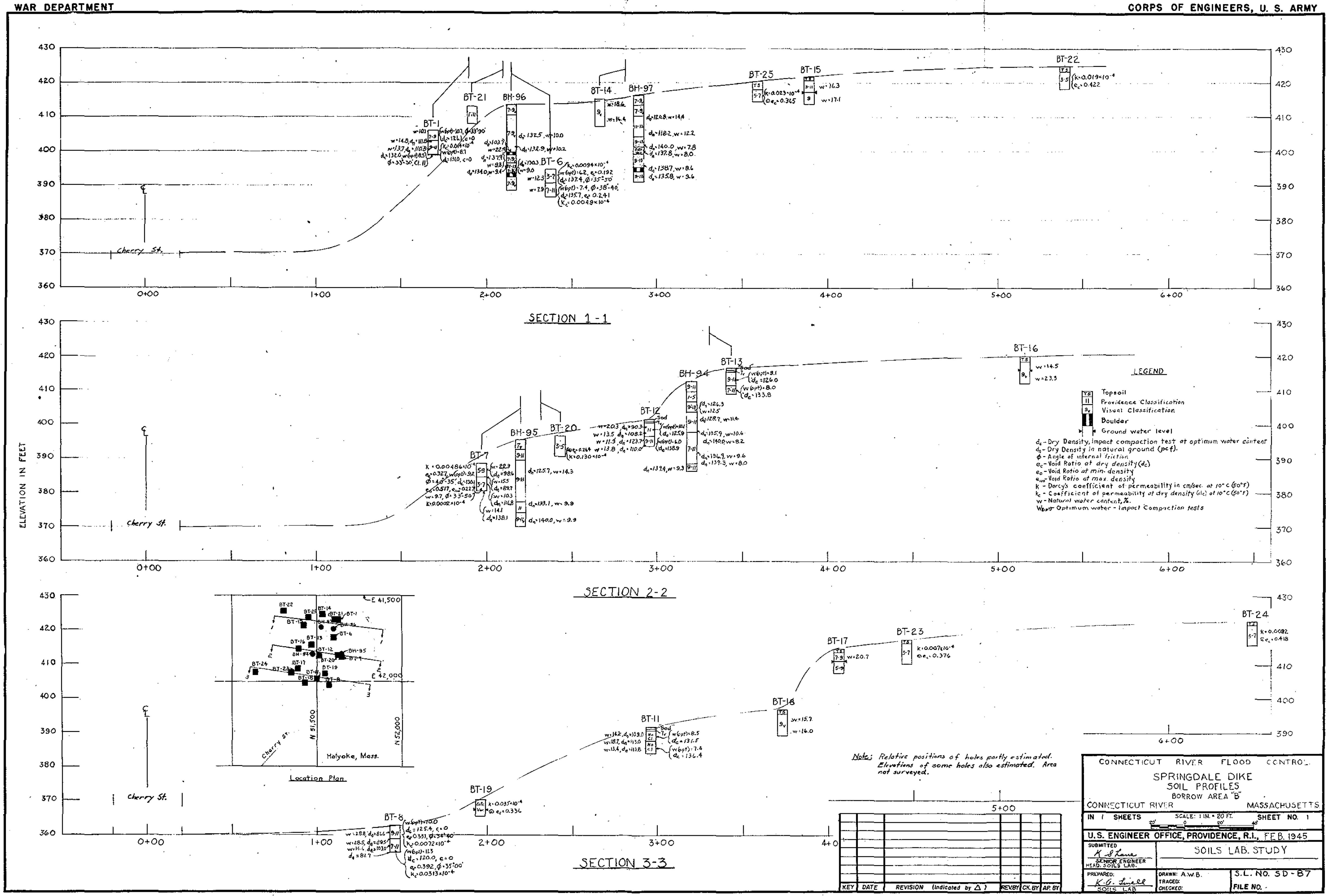
SUBMITTED: K. S. Lane, ENGINEER, HEAD, SOILS LABORATORY

SOILS LAB STUDY

PREPARED: R. A. Barron, SOILS LABORATORY

DRAWN: R.E.A.
TRACED:
CHECKED:

SL NO. Rd - 81
FILE NO.



CONNECTICUT RIVER FLOOD CONTROL

SPRINGDALE DIKE
SOIL PROFILES
BORROW AREA "B"

CONNECTICUT RIVER MASSACHUSETTS

IN 1 SHEETS SCALE: 1 IN. = 20 FT. SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., FEB. 1945

SUBMITTED: K. S. Lane, SENIOR ENGINEER, HEAD, SOILS LAB.

SOILS LAB. STUDY

PREPARED: K. G. Lisell, SOILS LAB.

DRAWN: A.W.B.
TRACED:
CHECKED:

S.L. NO. SD-87
FILE NO. -